U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
PB-299 101

Computerized FGD Byproduct Production and Marketing System: Users Manual

(U.S.) Tennessee Valley Authority, Muscle Shoals, AL

Prepared for

Industrial Environmental Research Lab, Research Triangle Park, NC

May 79

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/7-79-114	2.	3. RECIPIENT'S ACCESSION NO. PB299101
4. TITLE AND SUBTITLE Computerized FGD Byproduct Production and Marketing System: Users Manual		5. REPORT DATE May 1979 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) W. L. Anders		8. PERFORMING ORGANIZATION REPORT NO. ECDP B-2
9. PERFORMING ORGANIZATION NAME AND ADDRESS Tennessee Valley Authority Office of Power Emission Control Development Projects Muscle Shoals, Alabama 35660		10. PROGRAM ELEMENT NO. INE-624A 11. CONTRACT/GRANT NO. EPA IAG-D9-E721-BH
12. SPONSORING AGENCY NAME AND ADDRESS EPA, Office of Research and Development Industrial Environmental Research Laboratory Research Triangle Park, NC 27711		13. TYPE OF REPORT AND PERIOD COVERED Final; 1/78 - 1/79 14. SPONSORING AGENCY CODE EPA/600/13

15. SUPPLEMENTARY NOTES

IERL-RTP project officer is Charles J. Chatlynne, Mail Drop 61, 919/541-2915.

16. ABSTRACT

The users manual describes a computerized system—consisting of a number of integrated programs, models, and data bases—that has been developed to compare the costs of power plant strategies designed to meet clean air regulations. It describes the data bases, programs, and procedures and requirements that are necessary for data base access and program execution. The power plant data base contains actual and projected information for all U.S. fossil-fuel power plants. A scrubbing cost model allows cost comparisons between any two of five compliance strategies: limestone scrubbing with sludge waste disposal, limestone scrubbing with gypsum production, sodium sulfite scrubbing with sulfur production, magnesia scrubbing with sulfuric acid production, and the use of clean fuel with no scrubbing. For salable flue gas desulfurization (FGD) byproducts, cost comparisons include potential marketing revenues. The sulfur and sulfuric acid data base includes actual and projected information for all U.S. sulfur-burning acid plants. The transportation data base contains legal rail mileages between all rail rate basing points in the 37 Eastern States (Docket 28300) and also contains location-related data for every named U.S. location. Each data base and program can generally be used independently of the other parts of the system.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Cost Comparison	Pollution Control	13B	14A
Flue Gases	Electric Utilities	Stationary Sources	21B	
Desulfurization	Fossil Fuels		07A, 07D	21D
Byproducts	Gas Scrubbing		14B	13H
Marketing			05C	
Mathematical Models			12A	

18. DISTRIBUTION STATEMENT Unlimited	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 184
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE A09- A01

EPA Form 2220-1 (9-73)

EPA
United States
Environmental Protection
Agency
Industrial Environmental Research
Laboratory
Research Triangle Park NC 27711
EPA-600/7-79-114
May 1979

TVA
Tennessee Valley
Authority
Office of Power
Emission Control
Development Projects
Muscle Shoals Al 35660
ECDP B-2

PB 299101

Computerized FGD Byproduct Production and Marketing System: Users Manual

Interagency Energy/Environment R&D Program Report

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

EPA-600/7-79-114
ECDP B-2
May 1979

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EPA Interagency Agreement D9-E721-BH
Program Element No. INE-624A

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Research Triangle Park, NC 27711

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
Washington, DC 20460

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ABSTRACT

This users manual describes a computerized system consisting of a number of integrated programs, models, and data bases that have been developed to make cost comparisons among power plant strategies designed to meet clean air regulations. The data bases, programs, and the procedures and requirements that are necessary for data base access and program execution are described. The power plant data base contains actual and projected information for all U.S. fossil-fuel power plants. A scrubbing cost model allows cost comparisons between any two of five compliance strategies: limestone scrubbing with sludge waste disposal, limestone scrubbing with gypsum production, sodium sulfite scrubbing with sulfur production, magnesia scrubbing with sulfuric acid production, and the use of clean fuel with no scrubbing. For salable flue gas desulfurization (FGD) byproducts, potential marketing revenues are included in cost comparisons. The sulfur and sulfuric acid data base contains actual and projected information for all U.S. sulfur-burning acid plants. The transportation data base contains legal rail mileages between all rail rate basing points in the 37 eastern states (Docket 28300) and also contains location-related data for every named U.S. location. Each of the data bases and programs can generally be used independently of the other parts of the system.

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ABBREVIATIONS AND GLOSSARY

ABBREVIATIONS

ACFL	Alternative clean fuel level
CDC	Control Data Corporation
CDS	Compliance Data System
CENTRE	Centre Mark Company
EDS	Energy Data System
EPA	U.S. Environmental Protection Agency
FGD	Flue gas desulfurization
FIPS	Federal Information Processing Standard
FPC	Federal Power Commission
k	Thousand (10^3)
M	Million (10^6)
NEDS	National Emissions Data System
NRBT	National Rate Basis Tariff
PEDCo	PEDCo Environmental, Inc.
PLI	Procedural Language Interface
RJE	Remote Job Entry
SPLC	Standard Point Location Code
SRI	Stanford Research Institute

GLOSSARY

Alternative clean fuel level: The value assigned to premium price for fuel that will meet the sulfur oxide emission standard.

APEX: A comprehensive mathematical programing system including linear and mixed integer programing, matrix reduction, and parametric capabilities.

Capacity factor: Capacity factor is calculated as the ratio of the annual quantity of heat consumed in the boiler in comparison to the quantity that would have been consumed if the boiler had operated at rated capacity (full load) for the entire year (8760 hr).

Centre Mark Company: Source of geographic information on locations in the United States, including latitudes, longitudes, county data, and various other information related to over 100,000 locations.

Compliance Data System: A data base containing compliance information and status for all emission sources in the United States as they relate to clean air requirements.

CYBER 76 BATCH SERVICE: A computing service owned and operated by Control Data Corporation that provides greater computational speeds and capacities than those provided by the SCOPE 3.4 BATCH SERVICE.

CYBERLINK: A communications interchange to transmit information between the SCOPE 3.4 BATCH SERVICE, the CYBER 76 BATCH SERVICE, and the NOS INTERACTIVE AND BATCH SERVICE (registered trademark of CDC).

CYBERNET: A worldwide data processing and communications network owned and operated by Control Data Corporation (registered trademark of CDC).

Docket 28300: A general investigation by the Interstate Commerce Commission of the reasonableness of class rates in the United States (except in the mountain Pacific and transcontinental territories) that resulted in the class rates and tariffs in use today.

Energy Data System: A data base containing fuel quality and consumption data, plant design and operating data, emission regulations, compliance information, future megawatt capacities, and air quality data.

FPC Form 67: Federal Power Commission form used to report annual steam-electric plant and water quality control data.

Interactive time-sharing (also known as conversational time-sharing): A mode of operation of a data processing system in which a series of user instructions and computer replies are exchanged on a one-by-one basis, effectively constituting a conversation or interaction that takes place between the user and the computer.

Limestone slurry scrubbing: A process for removing sulfur oxides from flue gases by scrubbing the gases with a limestone slurry. In the case of sludge waste, the resulting slurry of calcium sulfites, sulfates, and unreacted limestone is discarded in a disposal pond. In the case of gypsum production, the slurry is oxidized to gypsum, dewatered, and stored.

Magnesia slurry scrubbing: A regenerative process for the removal of sulfur oxides from flue gases by scrubbing the gases with a magnesium oxide slurry. The magnesium sulfite formed in the slurry is removed and thermally decomposed into magnesium oxide and a stream of concentrated sulfur dioxide gases. The regenerated magnesium oxide is returned to the scrubbing tower and the concentrated sulfur dioxide stream is fed to a conventional contact sulfuric acid plant for the production of commercial (98%) sulfuric acid.

NAMELIST: A FORTRAN programing specification that permits input and output of groups of variables and arrays with an identifying name.

National Emissions Data System: A computer-based EPA emission inventory system for storing and retrieving estimates of the criteria pollutants from both point and area sources.

National Rate Basis Tariff: Tariff containing alphabetical lists of all rail stations with rate basis applicable.

NOS INTERACTIVE AND BATCH SERVICE: A computing service owned and operated by Control Data Corporation that provides both interactive time-sharing and small-to-medium batch processing capabilities.

PEDCo Environmental, Inc.: The company that gathers information under contract to EPA on FGD by direct interviews with and surveys of utilities in the United States.

Procedural Language Interface: A SYSTEM 2000 Procedural Language Interface establishes communications between a FORTRAN or COBOL program and a SYSTEM 2000 data base.

Remote batch processing: A mode of operation of a data processing system in which a series of user instructions are submitted to a computer as a single entity (called a run or job) using a remote job entry terminal and a data link (such as a telephone line), rather than using the input facilities of the central computer site (called on-line or over-the-counter batch processing). Once the computer begins performing the series of tasks it continues until processing is completed, and the results are returned to the user as a single entity using the remote terminal and data link.

Remote job entry: See remote batch processing above.

SCOPE 3.4 BATCH SERVICE: A computing service owned and operated by Control Data Corporation that provides medium- to large-scale batch processing capabilities.

Sodium scrubbing (Wellman-Lord/Allied Chemical process): A regenerative process for the removal of sulfur oxides from flue gases by scrubbing the gases with a solution of sodium sulfite. The sodium bisulfite formed is thermally decomposed to sodium sulfite and sulfur dioxide gas. The regenerated sodium sulfite is returned to the scrubbing tower and the sulfur dioxide is reduced with natural gas to form molten sulfur.

Standard Point Location Code: A transportation-oriented 6-digit number prescribed by the National Motor Freight Association under the guidance of the SPLC policy committee. It is used as a logistical linkage between all possible shipping origins and destinations for truck and/or rail.

SYSTEM 2000: A hierarchical data management system for creating, maintaining, and retrieving information from large data bases (registered trademark of MRI Systems Corporation).

COMPUTERIZED FGD
BYPRODUCT PRODUCTION AND MARKETING SYSTEM:
USERS MANUAL

I. INTRODUCTION

The U.S. Environmental Protection Agency (EPA) - Tennessee Valley Authority (TVA) studies of byproduct marketing for flue gas desulfurization (FGD) processes have been in progress since the early 1970's. During these studies a computer model consisting of a system of programs and data bases was developed for the numerous computation processes involved. As the system was refined and expanded to meet increasingly complex requirements, it became evident that it could also be generally useful as a tool in decision making involving a wide range of emission abatement problems.

In general, power plants out of compliance with clean air standards have two options. They can reduce the pollutants in the fuel burned, a clean fuel strategy, or they can remove pollutants after the fuel is burned, a scrubbing strategy. Scrubbing strategies are varied but they can be grouped into two basic categories: those that produce a waste or "throwaway" byproduct and those that produce a marketable byproduct.

A scrubbing system that produces a marketable byproduct such as sulfuric acid is not a practical strategy for all power plants because markets would quickly become saturated and revenues would be adversely affected. A scrubbing system that produces waste byproducts is not satisfactory in every case because of disposal problems, delivered raw material costs, and plant operating characteristics. Neither will the exclusive use of a clean fuel strategy solve the problem for all plants. The supply of naturally occurring clean fuel is limited and significantly increased demands would result in fuel price increases. The costs of cleaning fuel, such as coal washing, may also be prohibitive. Consideration must, therefore, be given to engineering, economic, transportation, and marketing factors to allow in-depth analyses that will result in selecting a suitable strategy for particular power plants. Since many strategies may be selected that result in compliance with clean air requirements, information must be available to make decisions that result in the least cost of compliance in the long run.

To provide an additional basis for cost analyses and comparisons in decisions involving alternate emission control strategies it was felt that the computer system developed for byproduct marketing studies should be made available for access on a commercial, nationwide, interactive time-sharing and remote batch data-processing network.

This manual provides the information and procedures necessary to use the system. It is primarily intended for the analyst-programer but it should also be useful to those requiring detailed information about the system who do not have extensive systems or programing experience.

This manual is primarily a users manual, however, and does not provide the concepts and background information necessary for use of the system. Several publications prepared during the course of byproduct marketing studies are essential in the use of this manual and should be used as references. *Marketing Sulfuric Acid from SO_2 Abatement Sources--The TVA Hypothesis* (1), *Potential Abatement Production and Marketing of Byproduct Sulfuric Acid in the U.S.* (2), and *Potential Production and Marketing of FGD Byproduct Sulfur and Sulfuric Acid in the U.S. - 1983 Projection* (3), provide background information and data. *Detailed Cost Estimates for Advanced Effluent Desulfurization Processes* (4) defines the cost estimates upon which the system is based.

The byproduct marketing system is available through TVA under a technology transfer agreement with EPA. Procedures for releasing the system are initiated upon receipt of a written request. At the present time, under the same technology transfer agreement, selected runs of the system based on user-supplied data can be made by TVA. The section on system usage provides the necessary details. All inquiries concerning the byproduct marketing system and this manual should be directed to Emission Control Development Projects, Tennessee Valley Authority, Muscle Shoals, Alabama 35660, telephone No. (205) 383-4631, extension 2516.

II. SYSTEM DESCRIPTION

The byproduct marketing system (Figure II-1) consists of a number of integrated computer programs, models, and data bases which can be used to make cost comparisons of FGD strategies designed to meet clean air regulations. For strategies which produce a salable byproduct the marketability of the byproduct is determined and its effect on FGD costs is included in the cost comparisons. The power plant data base contains actual and projected information on over 900 U.S. power plants. The system can use this data or user-supplied data to develop situations for comparison of alternate FGD strategies. Any two of five strategies can be compared in the current system: the use of clean fuel without FGD, limestone scrubbing with sludge waste disposal, limestone scrubbing with gypsum production, sodium scrubbing with sulfur production, and magnesia scrubbing with sulfuric acid production. For comparisons based on the use of clean fuel without FGD, an alternative clean fuel level (ACFL) is used to reflect the cost differential between a complying fuel and a noncomplying fuel. In the case of magnesia scrubbing with sulfuric acid production, the system determines the marketability of the acid produced at a price sufficient to recover the incremental cost of its production. For this capability, data bases on sulfur and sulfuric acid transportation costs and the U.S. sulfuric acid manufacturing industry are included in the system.

The entire system can be used to compare the magnesia scrubbing strategy with either the limestone scrubbing or clean fuel strategies for any combination of geographic and power plant situations. The numerous subsystems, programs, and data bases can be used separately or in various combinations to provide information on a wide range of related FGD processes and on sulfuric acid manufacture, transportation, and marketing. Provisions for sulfur marketing are being incorporated into the system. When this is completed, the system capabilities that are described for sulfuric acid throughout this manual will also apply to sulfur.

The system is in continual use and is updated and refined to reflect the best current information and technology. It is developed on the Control Data Corporation CYBERNET system with provisions for interactive time-sharing services and remote batch processing.

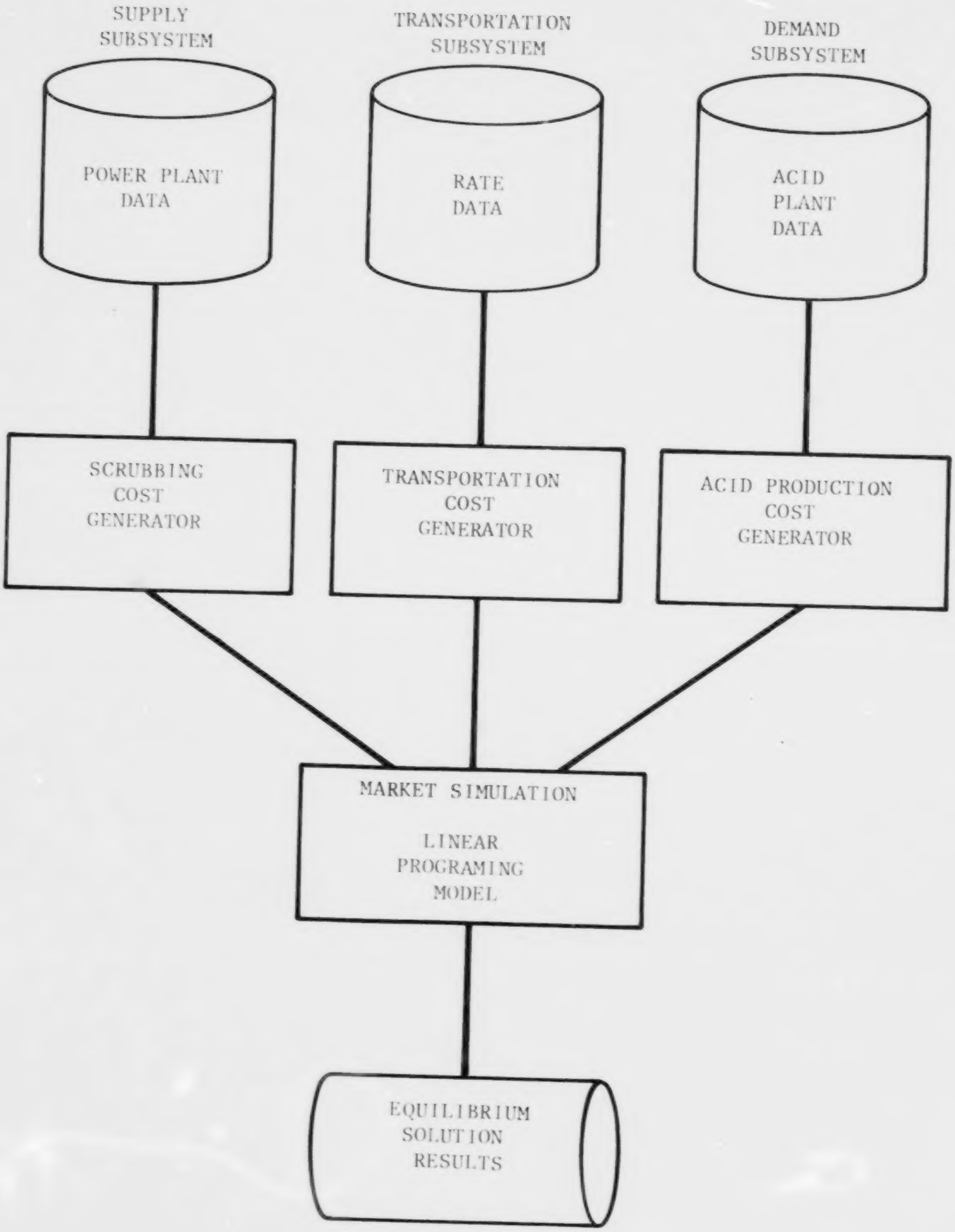

SUPPLY SUBSYSTEM
TRANSPORTATION SUBSYSTEM
DEMAND SUBSYSTEM
POWER PLANT DATA
RATE DATA
ACID PLANT DATA
SCRUBBING COST GENERATOR
TRANSPORTATION COST GENERATOR
ACID PRODUCTION COST GENERATOR
MARKET SIMULATION
LINEAR PROGRAMING MODEL
EQUILIBRIUM SOLUTION RESULTS

Figure II-1. Byproduct marketing system.

DATA SOURCES

Much of the data used in this system exists in other automated systems and published reports. In this system, however, it is organized as an integrated structure of power plant data, emission regulations, emissions data, compliance strategies, compliance costs, byproduct production, potential markets for salable byproducts, transportation costs for salable byproducts, and projections of net revenues resulting from the sale of byproducts. The primary data sources include Federal Power Commission (FPC) Form 67 data; the EPA Energy Data System (EDS); the Compliance Data System (CDS); a special report from the U.S. Bureau of Mines on limestone sources and costs; EPA's Utility FGD Survey prepared by PEDCo Environmental, Inc., (PEDCo); TVA-EPA engineering cost estimates of FGD processes; Centre Mark Company (CENTRE) geographic data for latitudes and longitudes of shipping points; Standard Point Locator Codes (SPLC); Federal Information Processing Standard (FIPS) codes; National Rate Basis Tariff (NRBT) data; Docket 28300 transportation-related data; TVA's Worldwide Fertilizer-Related Data Base (sulfuric acid data); elemental sulfur source and transportation data; National Emissions Data System (NEDS) data; and Stanford Research Institute (SRI) reports on sulfuric acid plants.

PREMISES

The system is based on an extensive set of premises which is fully covered in the referenced publications (1-4). Those most directly related to the development of the byproduct marketing system are discussed below.

The determination of costs for FGD systems is based on economic premises developed jointly by EPA and TVA which permit comparison of different systems using a common basis for developing capital costs and annual revenue requirements. These costs can be further developed to a single yearly cost which is comparable between FGD systems evaluated on the same premise set. The incremental cost difference between systems can thus be directly related to other costs or revenues--in this case revenue from the sale of sulfuric acid.

In most cases FGD systems producing a salable byproduct are more expensive than either the use of clean fuel or the use of a scrubbing system producing a waste byproduct. The higher cost of the marketable-byproduct-producing system is, however, reduced to some degree by sale of the byproduct. The byproduct sales price used to analyze marketing potential is a minimum price rather than a projection of an actual price. The minimum price used is determined by the total additional (incremental) cost associated with producing and marketing a salable byproduct, compared to the costs of producing a waste byproduct. The total incremental cost consists of the actual production-related investment and operating costs and transportation costs to the demand points. If the incremental costs can be recovered, the two systems compared will be economically equivalent and a marketable byproduct strategy will be selected.

The model does not consider either the cost benefits which might be derived from net sales revenue in excess of the incremental costs or the distribution of these benefits between the power plant producer and the acid plant consumer. It determines if the quantity of acid produced under the power plant conditions and locations specified can be disposed of at the price fixed by the incremental cost between the FGD systems compared.

Another important premise is that power plants will not establish extensive marketing systems but will sell to sulfuric acid producers manufacturing acid from sulfur. It is assumed that the producers will reduce their own production accordingly if purchase of power plant acid is economically attractive. An important portion of the byproduct marketing system is therefore the determination of manufacturing costs for acid producers as compared to purchase of the power plant acid.

The byproduct marketing system does not calculate compliance costs in terms of total dollars. Far too many variables are involved for a single total dollar value alone to be meaningful; instead, many factors such as equipment costs, capital and investment costs, and operating costs are integrated and reduced to a projection of costs in terms of cents/MBtu. This figure is more useful in the analysis of the various alternatives available because it permits comparisons of predictable and controllable plant and boiler operating factors and fuel characteristics. Neither does the system attempt to maximize benefits for a single power plant or acid plant; instead, a solution is provided that results in maximum cost savings for both industries combined, considering the interaction of all power plants and acid plants at the same time. The number of power plants and acid plants considered in the model can be controlled so that subsets of either or both industries can be considered. A marketing model can also be constructed for any subset. However, equilibrium solutions generated for the current studies address both industries as a whole.

SYSTEM ORGANIZATION

The overall system was shown diagrammatically in Figure II-1. It can be divided into four subsystems: the supply subsystem (Figure II-2) in which data related to FGD systems and byproduct production are generated, the demand subsystem (Figure II-3) in which data related to acid producers are generated, the transportation subsystem (Figure II-4) in which byproduct-related transportation costs are generated, and the linear programing subsystem (Figure II-5). The linear programing subsystem uses data from the other subsystems to develop a model and produce an optimum equilibrium solution. The system develops solutions on a case-by-case basis that will result in maximum benefit to both industries when considered as a whole.

Execution of the total system is a complex and costly task. Significant savings can be realized by proper planning and analysis; runs of selected parts of the system as opposed to running the total system may

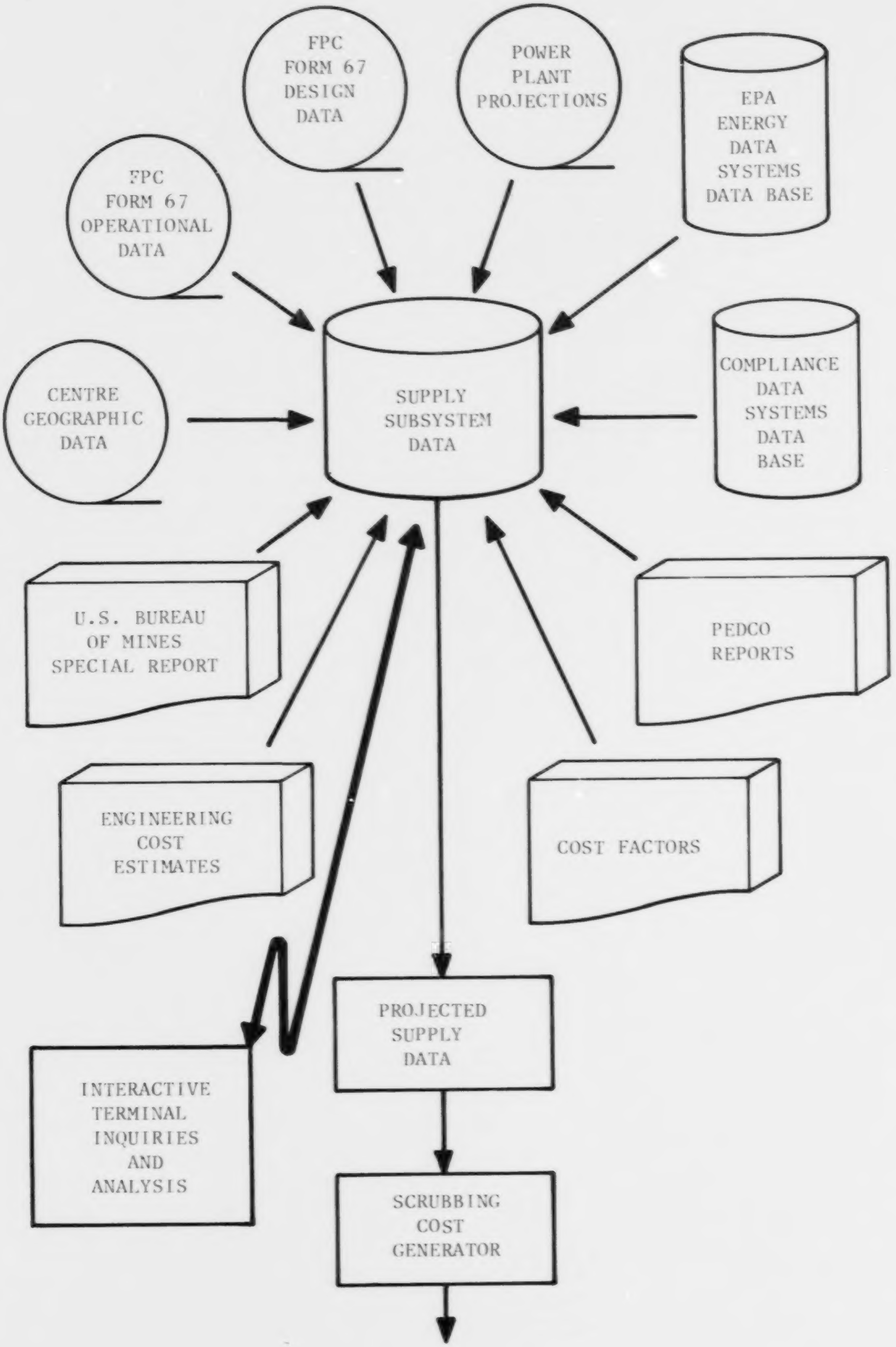

FPC FORM 67 DESIGN DATA
POWER PLANT PROJECTIONS
EPA ENERGY DATA SYSTEMS DATA BASE
FPC FORM 67 OPERATIONAL DATA
SUPPLY SUBSYSTEM DATA
CENTRE GEOGRAPHIC DATA
COMPLIANCE DATA SYSTEMS DATA BASE
U.S. BUREAU OF MINES SPECIAL REPORT
PEDCO REPORTS
ENGINEERING COST ESTIMATES
COST FACTORS
PROJECTED SUPPLY DATA
INTERACTIVE TERMINAL INQUIRIES AND ANALYSIS
SCRUBBING COST GENERATOR

Figure II-2. Supply subsystem.

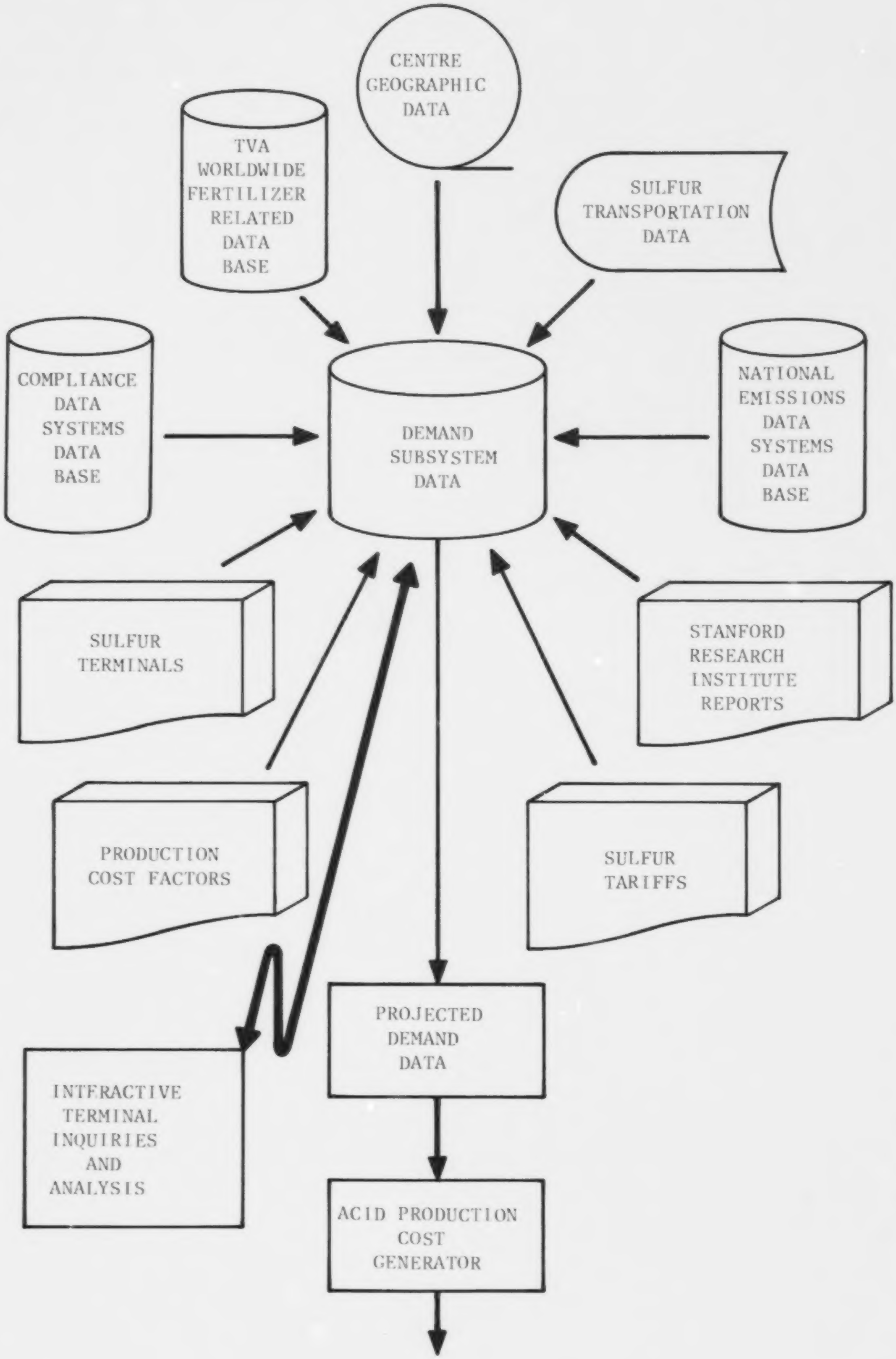

CENTRE GEOGRAPHIC DATA
TVA WORLDWIDE FERTILIZER RELATED DATA BASE
SULFUR TRANSPORTATION DATA
COMPLIANCE DATA SYSTEMS DATA BASE
DEMAND SUBSYSTEM DATA
NATIONAL EMISSIONS DATA SYSTEMS DATA BASE
SULFUR TERMINALS
STANFORD RESEARCH INSTITUTE REPORTS
PRODUCTION COST FACTORS
SULFUR TARIFFS
PROJECTED DEMAND DATA
INTERACTIVE TERMINAL INQUIRIES AND ANALYSIS
ACID PRODUCTION COST GENERATOR

Figure II-3. Demand subsystem.

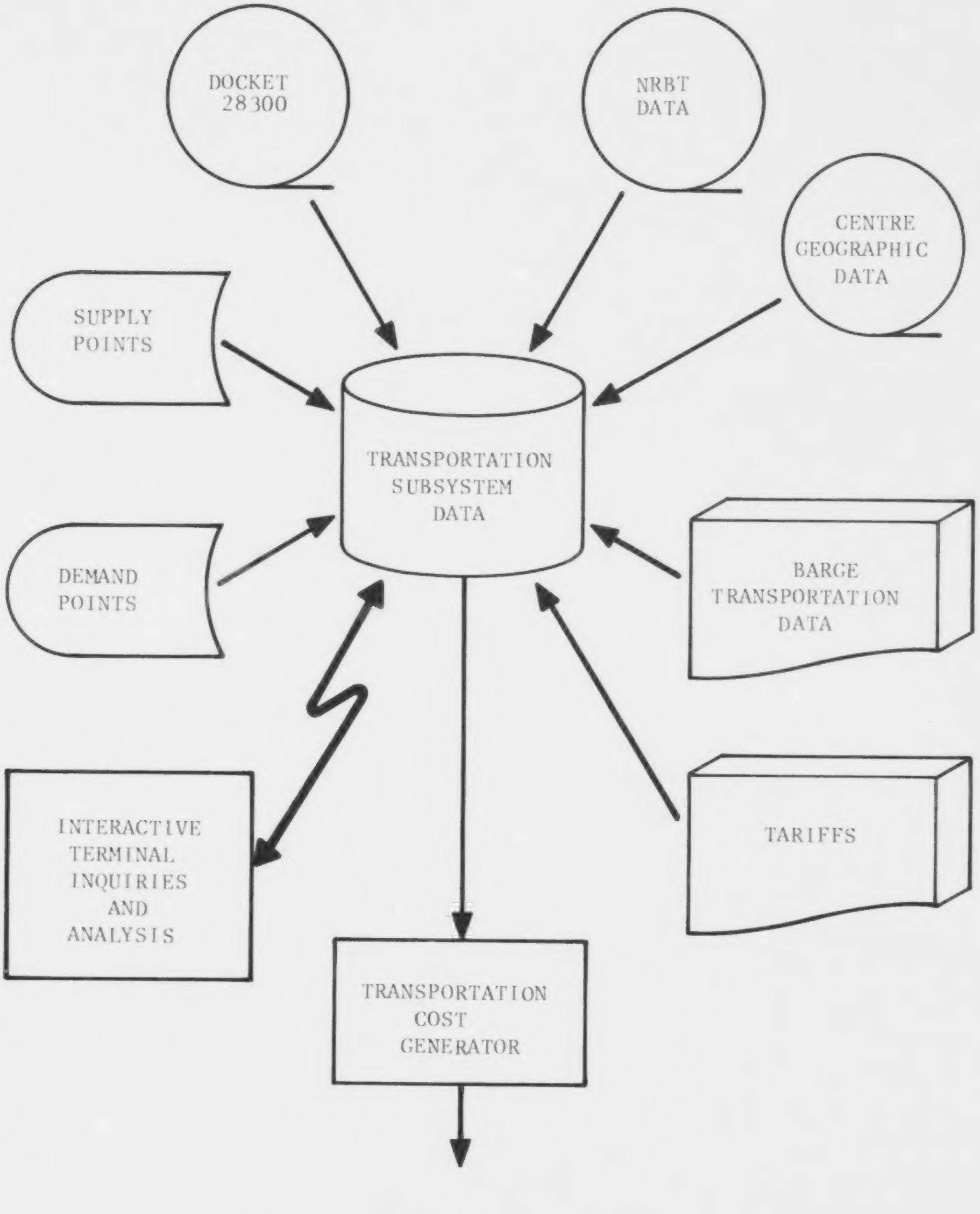

DOCKET 28300
NRBT DATA
CENTRE GEOGRAPHIC DATA
SUPPLY POINTS
TRANSPORTATION SUBSYSTEM DATA
DEMAND POINTS
BARGE TRANSPORTATION DATA
INTERACTIVE TERMINAL INQUIRIES AND ANALYSIS
TARIFFS
TRANSPORTATION COST GENERATOR

Figure II-4. Transportation subsystem.

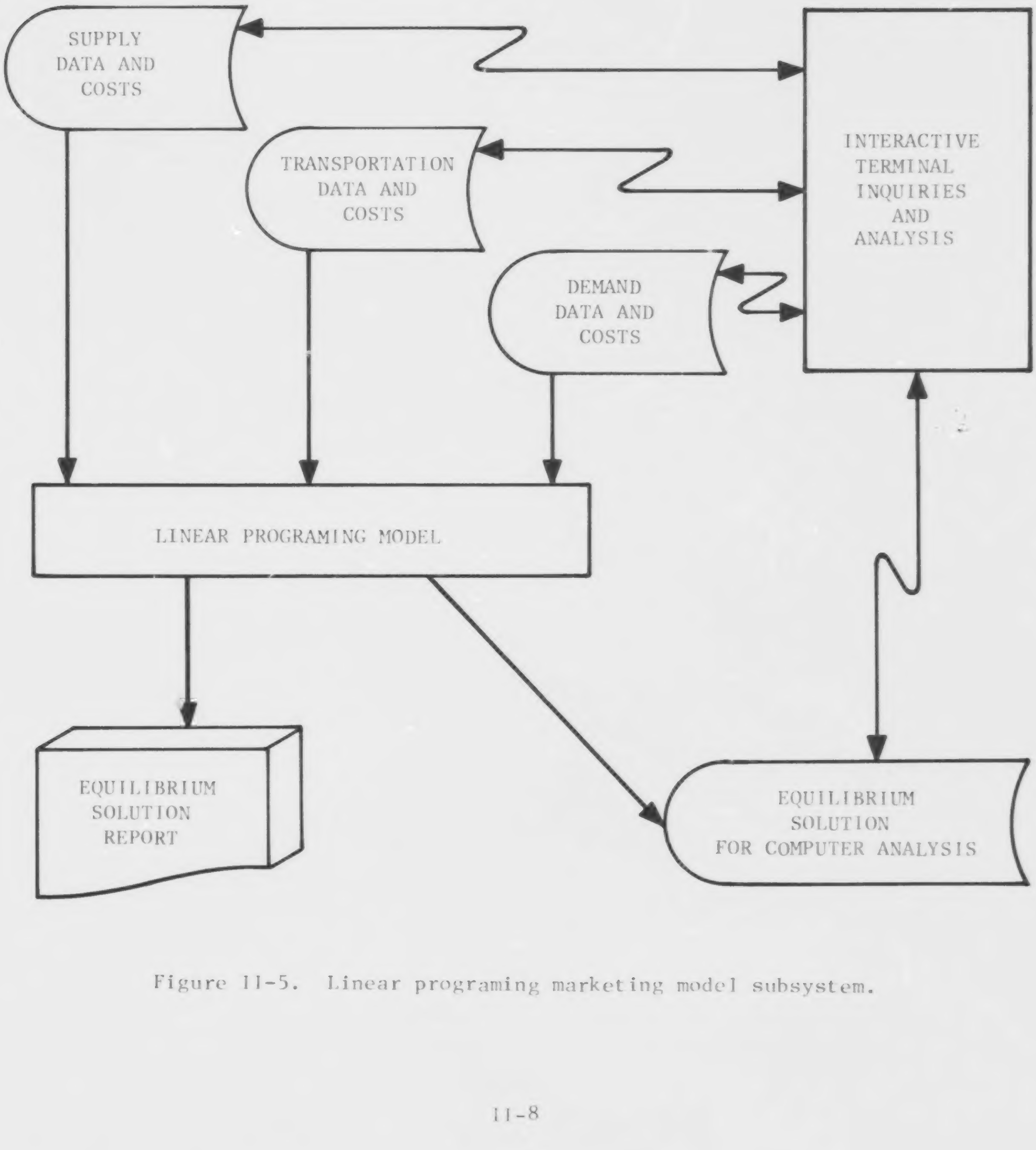

SUPPLY DATA AND COSTS
TRANSPORTATION DATA AND COSTS
DEMAND DATA AND COSTS
INTERACTIVE TERMINAL INQUIRIES AND ANALYSIS
LINEAR PROGRAMING MODEL
EQUILIBRIUM SOLUTION REPORT
EQUILIBRIUM SOLUTION FOR COMPUTER ANALYSIS

Figure II-5. Linear programing marketing model subsystem.

satisfy many requirements. All of the files, whether provided independently or generated within the system, are available for listing and analysis. In some cases an examination of the detailed results from the runs made for earlier studies may be adequate.

The execution of the system can be described in its simplest form as:

1. Execute the supply subsystem to project costs and quantities of supply.

2. Execute the demand subsystem to estimate the market (price and quantity) for the byproduct.

3. Execute the transportation subsystem to calculate the transportation costs for all possible combinations of supply points and demand points.

4. Execute the linear programing marketing model to determine the optimum combination of supply points, demand points, and transportation between them.

The preceding discussion and block diagrams (Figures II-1 through II-5) are useful for conceptual purposes only. Greater detail is required to show the actual interface of the data bases and programs that make up the system.

SUPPLY SUBSYSTEM

The supply subsystem as shown in Figure II-6 generally includes all of the data and programs that are related to power plants. Smelters are a special case of supply and for reasons described later are discussed as a part of the demand subsystem.

Supply Data Base

Four of the data files and the power plant data base used in the supply subsystem were developed independently of the normal system flow and are provided directly with no programs or procedures to generate them. Where modifications to these files are necessary they can be edited as needed. Modification capabilities for the power plant data base are not expected to be needed by users because the necessary data base values are extracted within the system and placed into standard sequential data files. The data files provided in addition to the power plant data base are (1) the scrubbing investment and operating factors based on the general cases developed in *Detailed Cost Estimates*, (2) scrubbing cost data by year which are time and area adjustments for the investment and operating factors in step 1, (3) site-factor adjustments for individual plants, which are modifications to the general case estimates of investment and operating costs based on known plant-specific

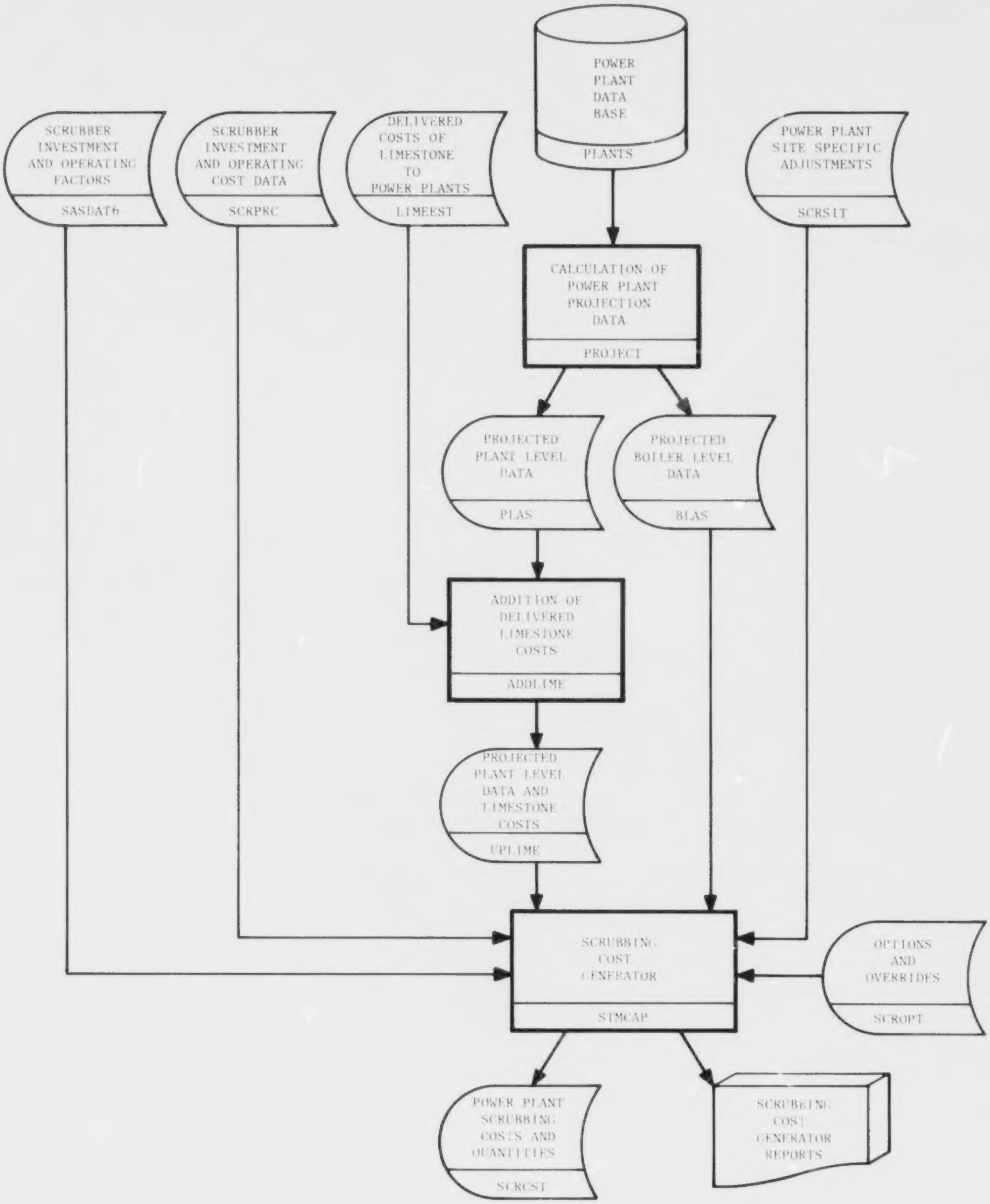

POWER PLANT DATA BASE
PLANTS
SCRUBBER INVESTMENT AND OPERATING FACTORS
SASDAT6
SCRUBBER INVESTMENT AND OPERATING COST DATA
SCRPRC
DELIVERED COSTS OF LIMESTONE TO POWER PLANTS
LIMEEST
POWER PLANT SITE SPECIFIC ADJUSTMENTS
SCRSIT
CALCULATION OF POWER PLANT PROJECTION DATA
PROJECT
PROJECTED PLANT LEVEL DATA
PLAS
PROJECTED BOILER LEVEL DATA
BLAS
ADDITION OF DELIVERED LIMESTONE COSTS
ADDLIME
PROJECTED PLANT LEVEL DATA AND LIMESTONE COSTS
UPLIME
SCRUBBING COST GENERATOR
STMCAP
OPTIONS AND OVERRIDES
SCROPT
POWER PLANT SCRUBBING COSTS AND QUANTITIES
SCRCST
SCRUBBING COST GENERATOR REPORTS

Figure II-6. Supply subsystem flow chart.

exceptions to the values normally used, and (4) a delivered cost of limestone for each power plant. All of these are described in section IV.

Supply Programs

The supply subsystem is made up of two major programs and a small data merge program. The major programs are the power plant data extract-projection program and the scrubbing cost generator program. They are both described in detail in section III. Even though the projection program is a major program, frequency of use is expected to be low because the output sequential files that it generates can be modified directly without executing the program. The supply subsystem as typically run consists of the following steps: (1) necessary corrections or additions are made to the data base and the four independent input files; (2) the projection program is modified as required and executed to extract the necessary data from the data base, and plant-level and boiler-level files of projected power plant data are created; (3) the delivered costs of limestone are added to the projected plant data file generated in step 2; and (4) the scrubbing cost generator program is executed. The scrubbing cost generator program can be executed in different modes depending upon specific requirements.

In addition to the mode described above in the typical execution of the system as a whole, the scrubbing cost generator program can be executed independently. Instead of plant and boiler input from the data base, specific input data can be prepared for plants, boilers, fuel characteristics, fuel consumption, compliance regulations, etc. Scrubbing costs can be developed based on these values completely independent of any data base values.

Several options are provided to control the level of output reports produced by the program. Reported results can vary, depending upon specifications provided, from very general, summary-level reports to very detailed reports showing many of the intermediate results in the calculations. Section III provides detailed information of these capabilities.

DEMAND SUBSYSTEM

The demand subsystem as shown in Figure II-7 consists of programs and data related to sulfuric acid production and the cost factors associated with it. All acid producers are grouped together in a single file with a code that indicates the feedstock used. The demand subsystem analyzes the feedstock code and selects only those producers burning elemental sulfur (referred to as acid plants for convenience) as potential buyers of power plant byproduct sulfuric acid. The acid producers using smelter off-gas as the feedstock (referred to as smelters for convenience) are not potential buyers of power plant byproduct acid; they are in fact competitors of the power plants for the sale of byproduct acid.

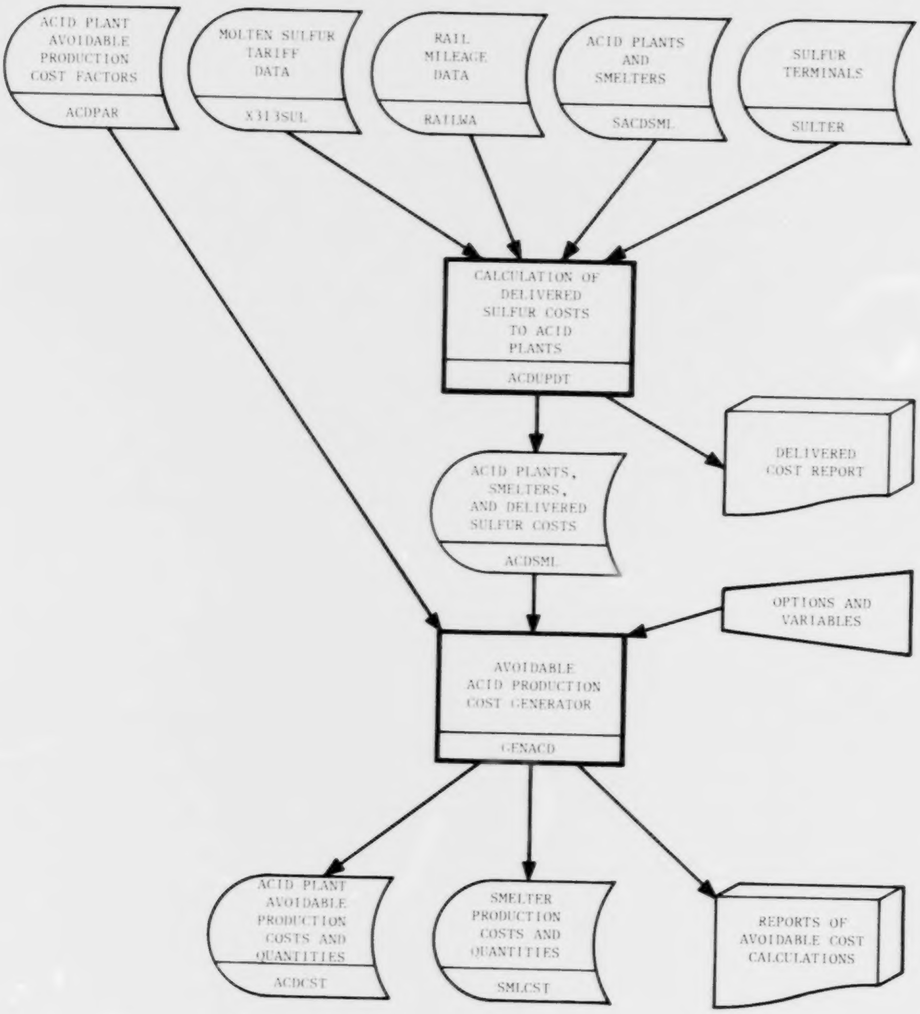

ACID PLANT AVOIDABLE PRODUCTION COST FACTORS
ACDPAR
MOLTEN SULFUR TARIFF DATA
X313SUL
RAIL MILEAGE DATA
RAILWA
ACID PLANTS AND SMELTERS
SACDSML
SULFUR TERMINALS
SULTER
CALCULATION OF DELIVERED SULFUR COSTS TO ACID PLANTS
ACDUPDT
DELIVERED COST REPORT
ACID PLANTS, SMELTERS, AND DELIVERED SULFUR COSTS
ACDSML
OPTIONS AND VARIABLES
AVOIDABLE ACID PRODUCTION COST GENERATOR
GENACD
ACID PLANT AVOIDABLE PRODUCTION COSTS AND QUANTITIES
ACDCST
SMELTER PRODUCTION COSTS AND QUANTITIES
SMLCST
REPORTS OF AVOIDABLE COST CALCULATIONS

Figure II-7. Demand subsystem flow chart.

Even though the market is assumed to be in equilibrium between supply and demand at some point in time, future production increases by the smelters will result in additional quantities of byproduct acid. Any market analysis and marketing model runs must take into account the increased production of smelter acid as well as power plant acid. A projected estimate of future production increases for all smelters is calculated based on their current capacity and compliance status with respect to clean air regulations. An additional production increase is projected for smelters out of compliance; the increased removal of sulfur dioxide required for compliance will result in a corresponding increase in abatement acid production. Because smelters are committed to the production of byproduct acid, whereas power plants have a wider choice of emission control alternatives, it is expected that they will be able to market their additional production before any power plant byproduct acid can be marketed unless transportation costs are prohibitive. For this reason the smelters are considered as having a zero unit production cost for the increased production which gives them an advantage over the power plants in the marketing model. Power plants will generally have a greater-than-zero unit production (incremental) cost. The smelters are separated from the acid plants that were also in the original input data and combined with the potential power plant byproduct acid producers to make up the total supply considered in the linear programing marketing model. The acid plants that remain in the original input data make up the total demand considered in the model.

Demand Data Base

Five of the data files used in the demand subsystem are provided as independent input files with no programs to generate them. These independent files were either generated manually from various sources or were already developed as a part of other studies. They are described in detail in section IV. As in the supply subsystem, the data can be changed as required or new records can be added if necessary. The independent data files provided are (1) values for calculating avoidable costs of acid production (investment costs, maintenance costs, fixed and variable production costs, delivered cost of sulfur, etc.), (2) tariff rates for sulfur, (3) rail mileages for all possible rate basing points, (4) acid plants and smelters--their location, capacity, etc., and (5) molten sulfur terminals.

Demand Programs

The demand subsystem is made up of two programs and various data files that determine potential byproduct acid consumers. The first program is used to calculate the delivered costs of elemental sulfur to each acid plant using the cheapest combination of barge and rail transportation from Port Sulphur, Louisiana, via the various molten sulfur terminals. The second program is used to calculate an estimated avoidable cost of acid production based on the results of the first program and plant capacity, plant efficiency, age, compliance status, etc. The smelters are processed by the programs and placed in a separate file as mentioned previously.

The calculation of the delivered cost of sulfur to each acid plant uses transportation-related data which are discussed in the transportation subsystem narrative. The transportation of sulfur by barge, however, applies only to the development of avoidable acid production costs. The documentation for the program that calculates the delivered cost of sulfur describes the procedure in detail. An NRBT rate basing point must be determined for any acid plants or sulfur terminals before they can be added to runs of the demand subsystem or of the system as a whole. More details are provided in the description of the transportation subsystem.

The demand subsystem is typically run in the sequence just presented. The second program may require several executions, varying the cost factors in each run to determine the effects of changes (both individually and in combination with other changes) on the calculated avoidable costs of sulfuric acid production. For more detailed information, refer to sections III and IV.

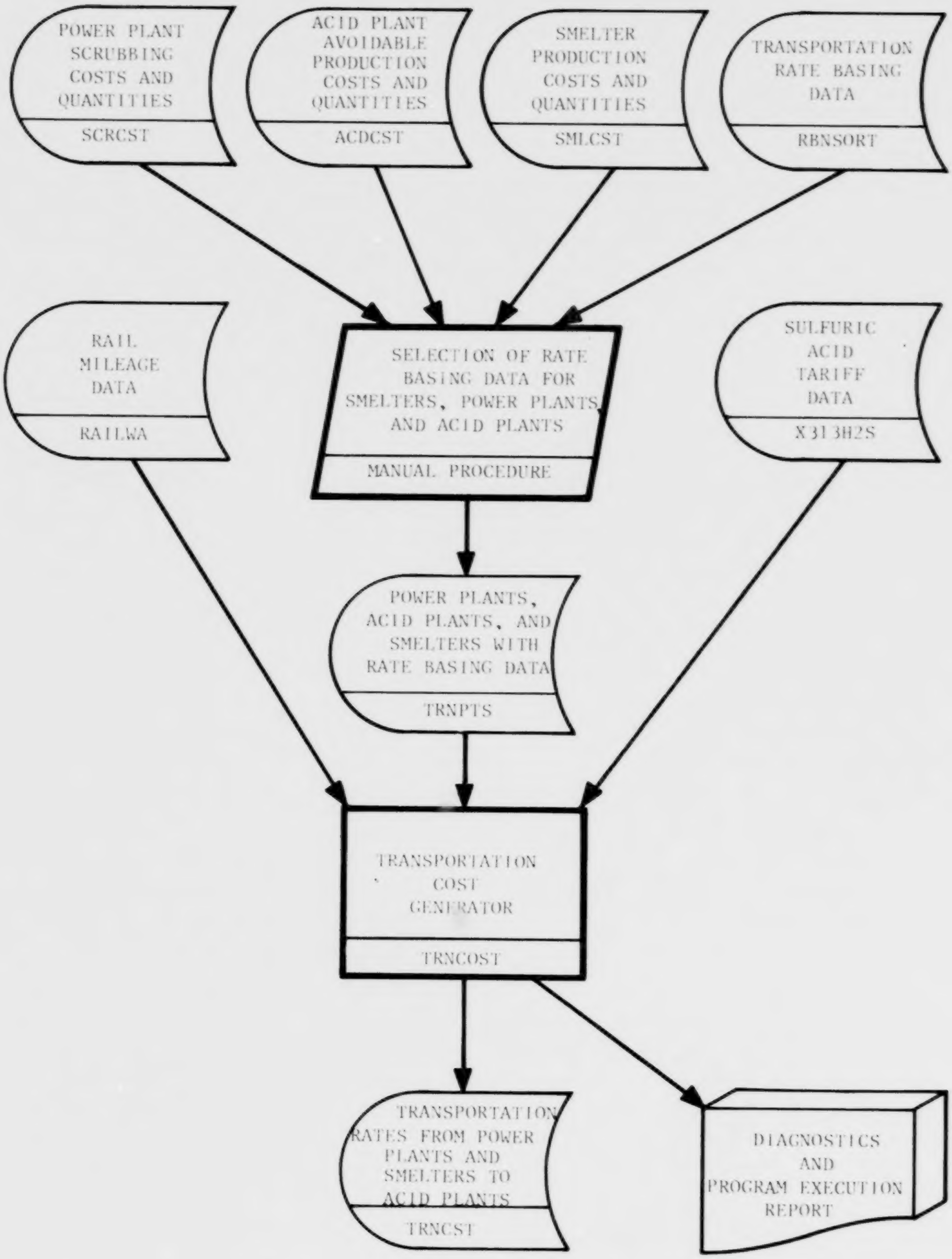
TRANSPORTATION SUBSYSTEM

The transportation subsystem (Figure II-8) consists of the programs and data required to calculate rail transportation costs from all potential suppliers to all potential consumers. Some of the data files are also used in the demand subsystem to calculate the contribution of sulfur transportation costs to avoidable production costs.

The transportation subsystem was designed on the basis that a totally automated transportation data base integrating all rail, barge, and truck data would be developed, along with the programs necessary for interface. The data base was created and the total size was over 25 million characters. It contains every named location in the 48 contiguous states for shipping by rail, barge, or truck. There are over 100,000 truck points, over 20,000 rail stations associated with the various rail carriers, and almost 2,000 barge points on the navigable inland waterway system.

The data base was designed to provide the information necessary to determine the least-cost method of shipment between any two locations via rail, barge, truck, or any combination of the three modes. Once the data base was created an analysis was made, based on the data base structure, of the computer costs required to link all truck points to the nearest rail and barge points and to link all rail points to the nearest barge point where applicable. In both cases the appropriate mileage between the points would also be included during the linking process. On the basis of potential benefits to the byproduct marketing system alone the cost of linking all points did not appear to be justified. As a result, the transportation subsystem is currently limited to rail except for the molten sulfur barge terminals.

More details on the integrated transportation data base are provided in Appendix A. There may be some potential for its use in other applications



POWER PLANT SCRUBBING COSTS AND QUANTITIES
SCRCST
ACID PLANT AVOIDABLE PRODUCTION COSTS AND QUANTITIES
ACDCST
SMELTER PRODUCTION COSTS AND QUANTITIES
SMLCST
TRANSPORTATION RATE BASING DATA
RBNSORT
RAIL MILEAGE DATA
RAILWA
SELECTION OF RATE BASING DATA FOR SMELTERS, POWER PLANTS AND ACID PLANTS
MANUAL PROCEDURE
SULFURIC ACID TARIFF DATA
X313H2S
POWER PLANTS, ACID PLANTS, AND SMELTERS WITH RATE BASING DATA
TRNPTS
TRANSPORTATION COST GENERATOR
TRNCOST
TRANSPORTATION RATES FROM POWER PLANTS AND SMELTERS TO ACID PLANTS
TRNCST
DIAGNOSTICS AND PROGRAM EXECUTION REPORT

Figure II-8. Transportation subsystem flow chart.

or systems. An additional reason for including the data base is that the final step of linking the locations may be completed in the future. If so, it should then be made an integral part of the byproduct marketing system.

Nonintegrated Transportation Data Base

Three of the data files used in the transportation subsystem are provided independently with no automated generation procedure. One of these files, the rail mileage file, is used in the demand subsystem. The rate basing point file is also required in the demand subsystem if new sulfur terminals or acid plants are added. The remaining file contains the tariff rates. Three other files (power plants, smelters, and acid plants) are also used for input data for the transportation subsystem but they are generated as an output of the two previous subsystems.

Transportation Programs

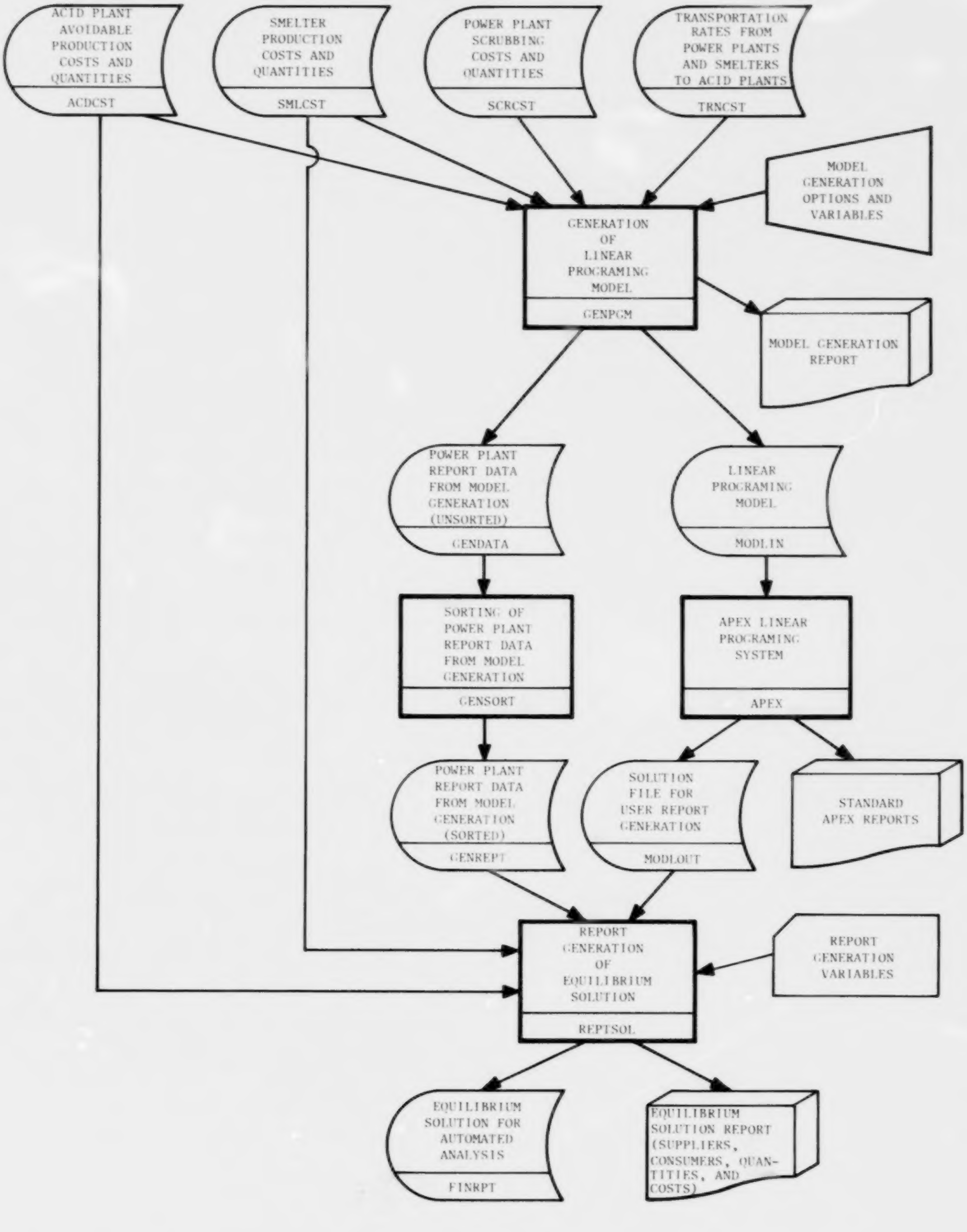
The transportation subsystem contains a manual procedure and a transportation cost generation program. A manual procedure is required because the fully integrated transportation data base is not currently used.

The manual procedure determines the rate basing point for each potential supplier, consumer, and sulfur terminal in the system. A part of this manual procedure must be completed before the demand subsystem discussed previously can be run when new locations are added. All mileage and tariff considerations rely on these rate basing points to determine shipping charges.

The transportation cost generation program calculates shipping costs for all possible combinations of potential suppliers and potential consumers by using the results of the manual procedure, the rail mileage file, and the applicable tariffs. The output file of transportation costs and the output data from the two previous subsystems complete the requirements for running the linear programing marketing model subsystem.

LINEAR PROGRAMING MODEL SUBSYSTEM

After the supply, demand, and transportation subsystems have been completed, the linear programing subsystem (Figure II-9) can be run. The subsystem consists of three main programs and a procedure to sort the data to be reported. The power plant, smelter, acid plant, and transportation data are inputs for the subsystem. The first program of the subsystem generates the linear programing model for APEX. APEX is an optimization system which produces the optimum result by maximizing gain or minimizing losses for the situation being considered. All of the data items in the input files are not usable in the model itself. They must be separated into another file with the necessary identification, sorted, and combined with the APEX results in the third program in order to provide a more descriptive report.



ACID PLANT AVOIDABLE PRODUCTION COSTS AND QUANTITIES
ACDCST
SMELTER PRODUCTION COSTS AND QUANTITIES
SMLCST
POWER PLANT SCRUBBING COSTS AND QUANTITIES
SCRCST
TRANSPORTATION RATES FROM POWER PLANTS AND SMELTERS TO ACID PLANTS
TRNCST
MODEL GENERATION OPTIONS AND VARIABLES
GENERATION OF LINEAR PROGRAMING MODEL
GENPGM
MODEL GENERATION REPORT
POWER PLANT REPORT DATA FROM MODEL GENERATION (UNSORTED)
GENDATA
LINEAR PROGRAMING MODEL
MODLIN
SORTING OF POWER PLANT REPORT DATA FROM MODEL GENERATION
GENSORT
APEX LINEAR PROGRAMING SYSTEM
APEX
POWER PLANT REPORT DATA FROM MODEL GENERATION (SORTED)
GENREPT
SOLUTION FILE FOR USER REPORT GENERATION
MODLOUT
STANDARD APEX REPORTS
REPORT GENERATION OF EQUILIBRIUM SOLUTION
REPTSOL
REPORT GENERATION VARIABLES
EQUILIBRIUM SOLUTION FOR AUTOMATED ANALYSIS
FINRPT
EQUILIBRIUM SOLUTION REPORT (SUPPLIERS, CONSUMERS, QUANTITIES, AND COSTS)

Figure II-9. Linear programing marketing model subsystem flow chart.

The third and final major program in the subsystem is the report generator which builds the final output report format. This program is required even though a standard output report is provided by the APEX system. The APEX report is very general and inflexible for descriptive presentation of results; therefore, another file is also provided to allow customized reporting of results. An on-line storage copy of the output produced by the report generator is written to allow further use if required. The subsystem is typically run in the sequence described above. A more detailed description is provided in sections III and IV.

A greater variation in run cost is more likely in this subsystem than in the previous ones so careful planning and evaluation of requirements are necessary. The use of batch versus interactive runs and avoidance of large model runs that may not be any more meaningful than a smaller scale run are very important in controlling costs.

SUMMARY

The system description section has been as general and basic as possible because the following program and data description sections are of necessity very specific and involved. Even though the overall system can be described conceptually so that it is relatively easy to understand, it is very complex at the operational level. Because of this complexity--and so that the functional aspects of each program and data file can be better analyzed using documentation in subsequent detailed sections--a final step-by-step summary may be useful. The preceding flow charts and narratives have shown the various relationships between the programs and data used in the system.

There are 12 basic steps in a typical system execution:

General

1. The power plant data base, the independent files, the programs, and the user procedures are loaded from magnetic tape to on-line storage.

Supply

2. The projection program executes, extracts the power plant-related data from the data base, and generates projected plant-level and boiler-level data files.

3. The limestone delivered cost program executes, adds from an independent file the delivered cost of limestone for each power plant to the projected plant data file created in step 2, and generates a combined projected plant data and limestone cost file.

4. The scrubbing cost generator program executes; uses the independent files of investment and operating data, cost data, and site-specific location factors; uses the projected plant-level data file created in step 2 and updated in step 3; and finally uses the projected boiler-level data file created in step 2; and generates a file of power plant scrubbing costs and quantities as well as various optional printed reports that have been selected.

Demand

5. The program to calculate delivered sulfur costs to acid plants executes; uses the independent files of acid plants and smelters, sulfur tariff rates, rail mileages, and sulfur terminals; and generates a file containing the delivered cost of sulfur to each acid plant and an optional printed report of the delivered costs.

6. The program to generate the avoidable production costs of sulfuric acid for each acid plant executes, uses the independent file of avoidable production cost factors and the acid plant file with delivered costs of sulfur generated in step 5, and generates a file of acid plants with their avoidable costs and quantities, a file of smelters with their production costs and quantities, and optional printed reports.

Transportation

7. The acid plant file and smelter file from step 6 and the power plant file from step 4 are examined manually and, where necessary, the independent file of rate basing points is used to select the appropriate rate basing point for each power plant, acid plant, and smelter. A transportation file based upon locations in the three input files is generated manually.

8. The transportation cost generator program executes; uses the independent files of rail mileages and sulfuric acid tariffs and the transportation file for power plants, smelters, and acid plants from step 7; and generates a file of transportation costs for every possible combination of shipments from power plants and smelters to acid plants and also a printed report related to the costs.

Linear Programing Marketing Model

9. The program to generate the linear programing model executes; uses the power plant file from step 4, the smelter file and acid plant file from step 6, and the transportation cost file from step 8; and generates the linear programing model based upon a user-provided ACFL value. It also generates a file of information that is not input to the model but is required for reporting results.

10. The APEX linear programing system executes, solves the linear programing model generated in step 9, and generates a file containing the solution that will be used in the report program. It also generates a standard report describing the solution.

11. The report generator program executes, uses the file containing the model solution generated in step 10 and the file of information for reporting created in step 9, and generates a printed report of the solution showing potential sales by power plants and smelters and potential purchases by acid plants (including the price received, price paid, and transportation costs for each transaction where applicable) as well as an on-line file of the report for further analysis.

12. The report from step 11 is analyzed. Based on the results of the market potential shown in the model solution and the ACFL used, final strategy selections are made for all power plants.

Because the independent files are not generated by the programs in the system and therefore have no detailed description of their creation, the data they contain should be analyzed carefully (refer to section IV). The resources expended in the research and development of these data files and data bases were at least as great as the resources required for developing the remainder of the system. The independent data include the power plant data base, delivered costs of limestone to each power plant, scrubber investment and operating factors, scrubber cost data, power plant site-specific adjustments associated with the various scrubbing processes, acid plant and smelter data, acid plant avoidable production cost factors, molten sulfur terminals, rate basing point data, rail mileage data, and sulfur and sulfuric acid tariffs. External files can generally be modified as required. The internal files can be modified either directly or by reexecution of the appropriate program.

III. PROGRAM DESCRIPTIONS

This section provides a general narrative and block diagram for all programs and procedures that make up the system. Each of the block diagrams is a subset of the detailed subsystem flow charts shown in section II (Figures II-6 through II-9). The narratives are intended to aid in usage, not to document all of the internal program details. A current source listing of the appropriate program must be referred to for exact coding details. This should not be necessary except for the most rigorous analysis and is not typically required for system execution.

This section and the following sections on file and record descriptions and systems usage require a greater understanding of the concepts of programing and data processing than did the preceding sections. The descriptions should still be of some value to those with no specialized background or training but the system is designed to execute on modern high-speed computers and it is impossible to avoid the terminology and concepts required for actual usage.

PROJECT PROGRAM

The projection program (Figure III-1) was designed to extract information from the power plant data base and generate the data projections required by the scrubbing cost generator. Because data must be projected for the industry as a whole, some generalizations, assumptions, and data default values must be used where individual data items are either not reported or are inconsistent with other values. When this occurs the values used are based upon extensive analyses of both current and historical data.

Users can enter specific data values into the generated plant and boiler records and override program projections if necessary. This is obviously not practical on a plant-by-plant basis for the whole industry which is made up of more than 900 power plants and 3500 boilers that have over 5 million characters of data associated with them in the data base.

Familiarity with the power plant data base is required during subsequent program documentation and section IV should be referred to as required. The projection program is the only interface between the byproduct marketing system and the power plant data base. It extracts all of the necessary information and writes the data to sequential files for use throughout the rest of the system. Based upon the data base description, the data categories required from the data base are (1)

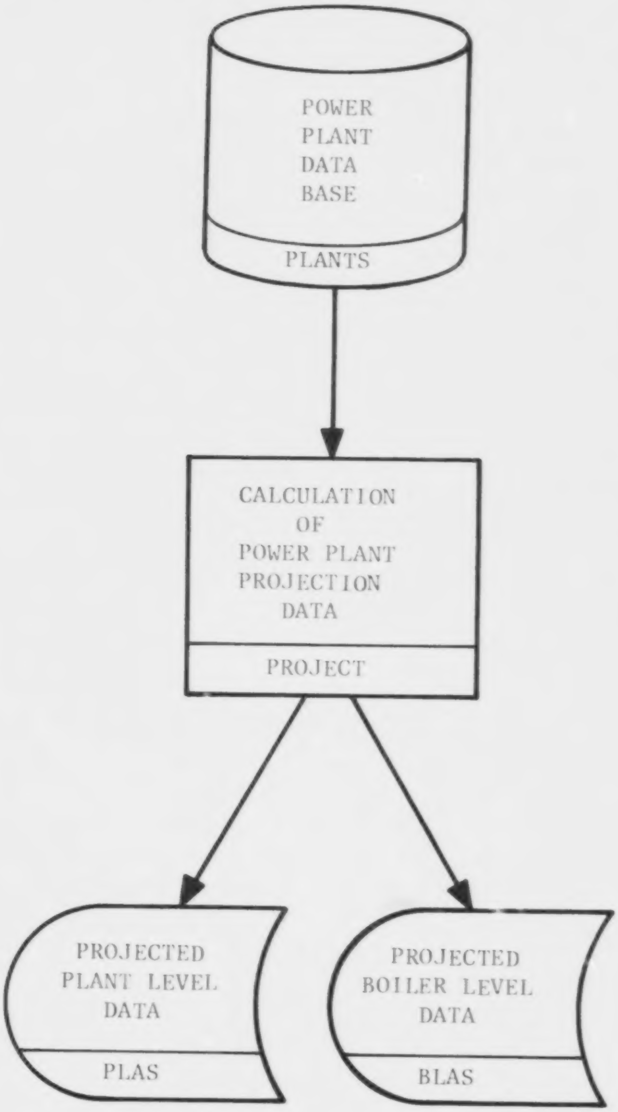

POWER
PLANT
DATA
BASE
PLANTS
CALCULATION
OF
POWER PLANT
PROJECTION
DATA
PROJECT
PROJECTED
PLANT LEVEL
DATA
PLAS
PROJECTED
BOILER LEVEL
DATA
BLAS

Figure III-1. Block diagram for the calculation of power plant projection data (program PROJECT).

general plant data, (2) plant data for both the base year and the year to be projected (1973 and 1978 in the original studies), (3) regulations, (4) regulations by pollutant, fuel type, and applicability, (5) general boiler data, (6) boiler/stack configuration data, and (7) boiler data by year (available for the base year, but not for the year to be projected because of the method of reporting on FPC Form 67).

Projections of future fossil-fuel usage (both quantities and characteristics) are reported by the utilities on FPC Form 67 and entered in the data base at the plant level, not the boiler level. Most of the clean air regulations apply at the boiler level and all scrubbing cost generator calculations related to compliance strategies and alternatives are made at the boiler level. An allocation method based upon historical relationships between plant-level and boiler-level operating characteristics and fuel consumption is used to analyze the plant-level data and derive data at a boiler level for the year to be projected. Although program projections for plants with no base-year boiler data could be made directly at the boiler level, all program projection estimates for plants with incomplete or no base-year boiler-level data are made at the plant level. As a result, the same procedure is used for all plants to derive data at the boiler level. Six separate cases of data conditions are identified for projection purposes.

Case 1 identifies plants for which both base-year boiler data and projection-year plant data are available.

Case 2 identifies plants for which base-year boiler data are available, projection-year plant data are not available, and plant capacity for the projection year is no more than 100 MW greater than the base-year plant capacity.

Case 3 is the same as case 2 except that it identifies plants for which the plant capacity in the projected year is over 100 MW greater than the base-year plant capacity.

Case 4 identifies plants for which neither base-year boiler data nor projection-year plant data are available. This case is included primarily for programing considerations.

Case 5 is currently not used.

Case 6 identifies plants that do not have base-year boiler data available but have projection-year plant data available.

The key factor in allocating fuel to the boiler level from the plant level is the boiler capacity factor. An analysis of historical boiler capacity factors using FPC data from 1969 through 1973 and *Detailed Cost Estimates* resulted in an algorithm based primarily on boiler age to estimate capacity factors for the projected year. It is recognized that there have been some major changes in fossil-fuel usage patterns along with related cost implications. These patterns should be reflected in new data as it become available and appropriate adjustments can be made if required.

Regulations may apply at the plant, stack, and boiler levels. When regulations apply at the plant level the appropriate regulations are included in the plant data record. When regulations apply at the boiler level, in most cases they apply for all boilers at a given plant and they are included in each boiler data record for that plant. For the cases where individual boilers have a specific regulation, the regulation that applies is included in the appropriate boiler data record.

If stack-level emission regulations apply, some problems exist. Power plants are designed with a wide variety of boiler - stack configuration options and these options are reflected in the reporting of data on FPC Form 67, which generally lists the options rather than actual or customary use. A procedure was developed with EPA concurrence to apply stack regulations at the boiler or total plant level. When a plant has only one stack all boilers obviously feed the same stack and stack-level regulations are treated as a plant-level regulation. When one-to-one boiler - stack configurations exist the stack regulations are applied as a boiler regulation. When multiple stack - boiler combinations exist and all stacks have the same regulation, each boiler is assigned the stack regulation value on a boiler-by-boiler basis. If stacks within a plant have different regulations each boiler reported to feed multiple stacks is assigned the most rigorous regulation of the stacks fed.

In actual usage plant- and stack-level regulations are expected to have little if any effect. The best candidates for byproduct marketing are relatively new boilers that typically have to meet Federal boiler-level emission standards.

The above procedures apply for each power plant in the data base. The results are written to two data files--plant data (PLAS) and boiler data (BLAS).

ADDLIME PROGRAM

The ADDLIME program (Figure III-2) is a merge program that reads the PLAS file created by the projection program and the independent LIMEEST file of delivered costs of limestone to each power plant and creates a combined output file. The output file, UPLIME, is saved so that the projection program will have to be run only when program changes are made or the power plant data base is updated. If a projection program run is made and the ADDLIME program is not run, the limestone cost field will be zero and the scrubbing cost generator program will use a constant default value for every plant instead of the value for each plant in the LIMEEST file.

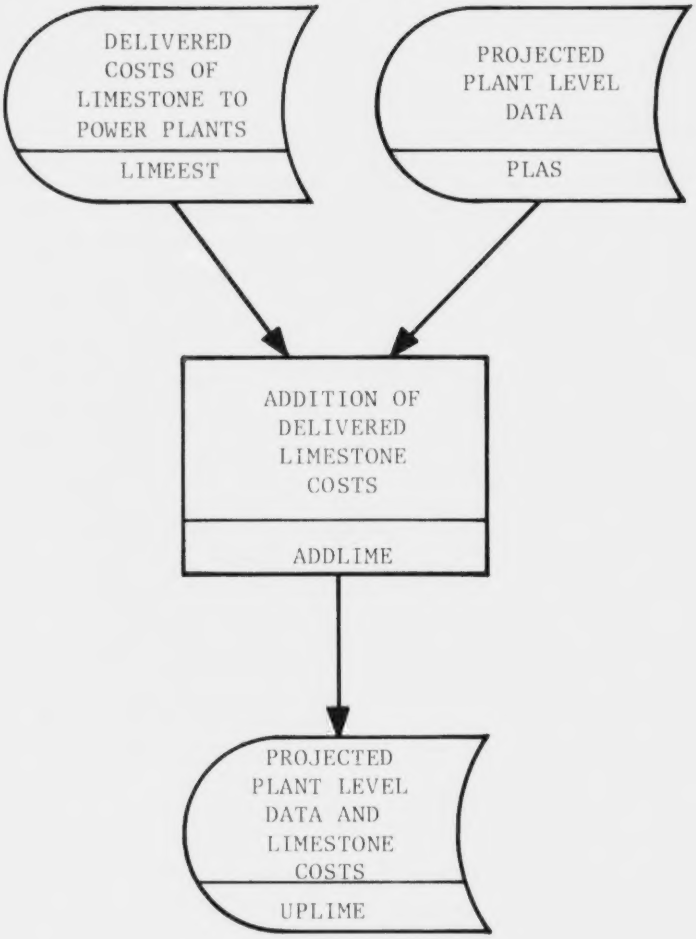

DELIVERED COSTS OF LIMESTONE TO POWER PLANTS
LIMEEST
PROJECTED PLANT LEVEL DATA
PLAS
ADDITION OF DELIVERED LIMESTONE COSTS
ADDLIME
PROJECTED PLANT LEVEL DATA AND LIMESTONE COSTS
UPLIME

Figure III-2. Block diagram for the addition of delivered limestone costs to power plants (program ADDLIME).

STMCAP PROGRAM

The scrubbing cost generator program (Figures III-3 and III-4) was designed to provide a consistent method for projecting comparative costs of installing FGD systems on power plants. Design capabilities include both cost and byproduct quantity projections for up to six FGD processes. Engineering data now included are limited to the use of clean fuel and the limestone, magnesia, sodium, and gypsum scrubbing processes; the remainder of the system relating to the marketing and transportation of abatement byproducts is now limited to sulfur and sulfuric acid, but the design capabilities of the program allow addition of other byproducts. When the overall program potential and the possible variations in its use are considered (such as the execution time options, input-data-modification options, override conditions, selection of output reports, and print options for displaying intermediate results of some of the more complex calculations) the scrubbing cost generator is by far the most complex program in the system.

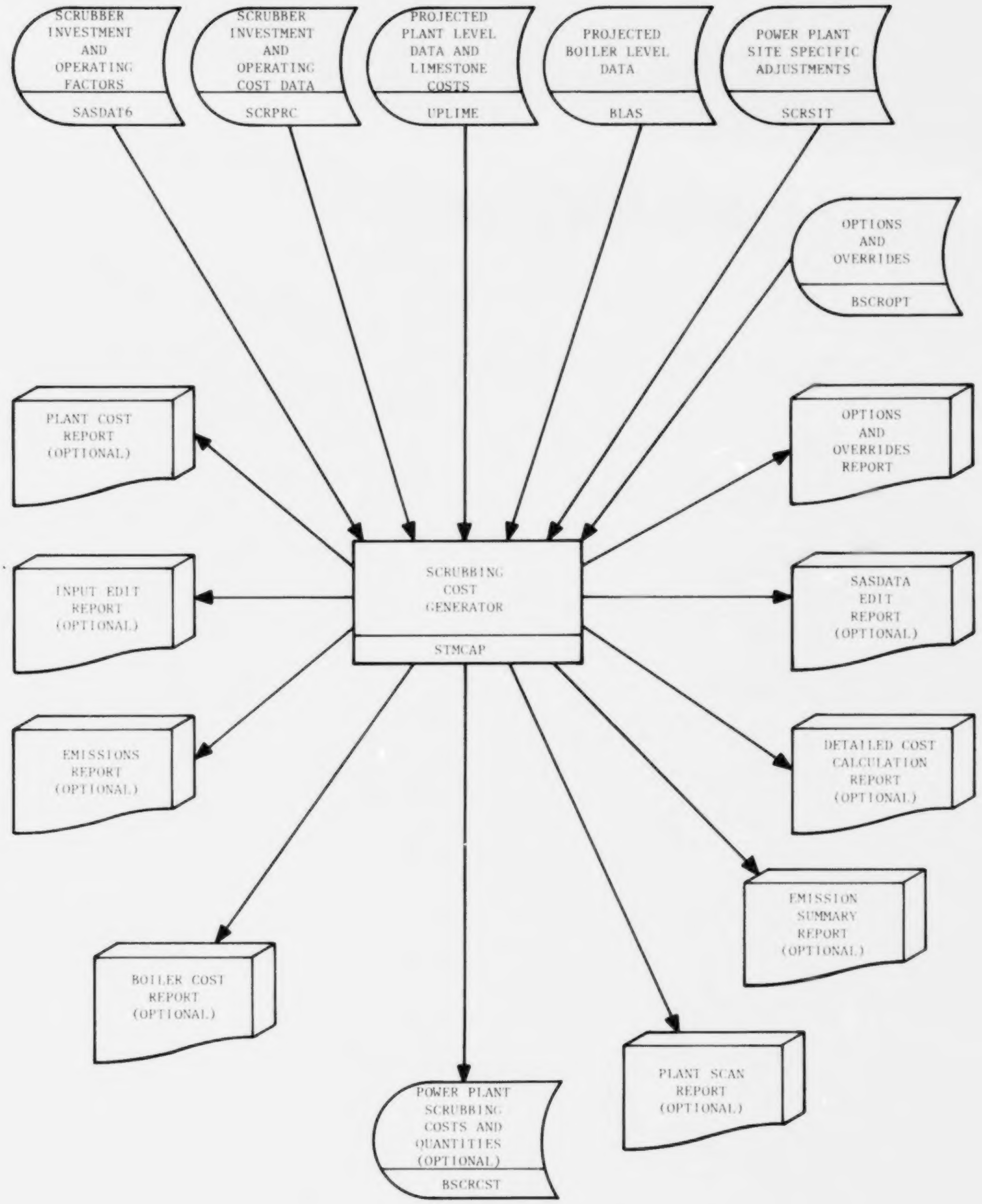
The results of the scrubbing cost generator have a critical influence on the remainder of the system. Selection of a strategy that will lead to compliance (clean fuel, a disposable byproduct process, or a marketable byproduct process) and the potential sales when a marketable process is indicated are both totally dependent upon the projected costs and quantities calculated for each compliance strategy by the scrubbing cost generator.

To minimize modifications to both the program and to the standard input data, program execution was designed for usage flexibility. However, this flexibility increases the procedural complexity associated with program execution. Because the internal program coding is also complex the overall requirements for usage are relatively difficult. A general discussion of the input and output should help to clarify details of the options and overrides that will be covered later.

Input

The primary source of input data used in the program (other than the power plant data) is the investment and operating data for the various scrubbing processes in *Detailed Cost Estimates*. Even a cursory analysis of this program and its results requires familiarity with that publication.

Program processing, whether accomplished using the supply subsystem (Figure III-3) or as an independent execution with user-supplied power plant data (Figure III-4), will always require the following input files: the independent file of investment and operating factors, the independent file of cost data, and the options and overrides to be used. The block diagram for this program when executed using the supply subsystem (Figure III-3) also shows an independent file of site-factor adjustments. If these are required this file should obviously be used, but it is optional as far as uninterrupted program processing is concerned. In any case the site-factor file will normally contain records for a limited number of plants. Specific site-factor adjustments are required



SCRUBBER INVESTMENT AND OPERATING FACTORS
SASDAT6
SCRUBBER INVESTMENT AND OPERATING COST DATA
SCRPRC
PROJECTED PLANT LEVEL DATA AND LIMESTONE COSTS
UPLIME
PROJECTED BOILER LEVEL DATA
BLAS
POWER PLANT SITE SPECIFIC ADJUSTMENTS
SCRSIT
OPTIONS AND OVERRIDES
BSCROPT
PLANT COST REPORT (OPTIONAL)
OPTIONS AND OVERRIDES REPORT
SCRUBBING COST GENERATOR
STMCAP
INPUT EDIT REPORT (OPTIONAL)
SASDATA EDIT REPORT (OPTIONAL)
EMISSIONS REPORT (OPTIONAL)
DETAILED COST CALCULATION REPORT (OPTIONAL)
EMISSION SUMMARY REPORT (OPTIONAL)
BOILER COST REPORT (OPTIONAL)
PLANT SCAN REPORT (OPTIONAL)
POWER PLANT SCRUBBING COSTS AND QUANTITIES (OPTIONAL)
BSCRCST

Figure III-3. Block diagram for the calculation of power plant scrubbing costs as a part of the overall system (program STMCAP).

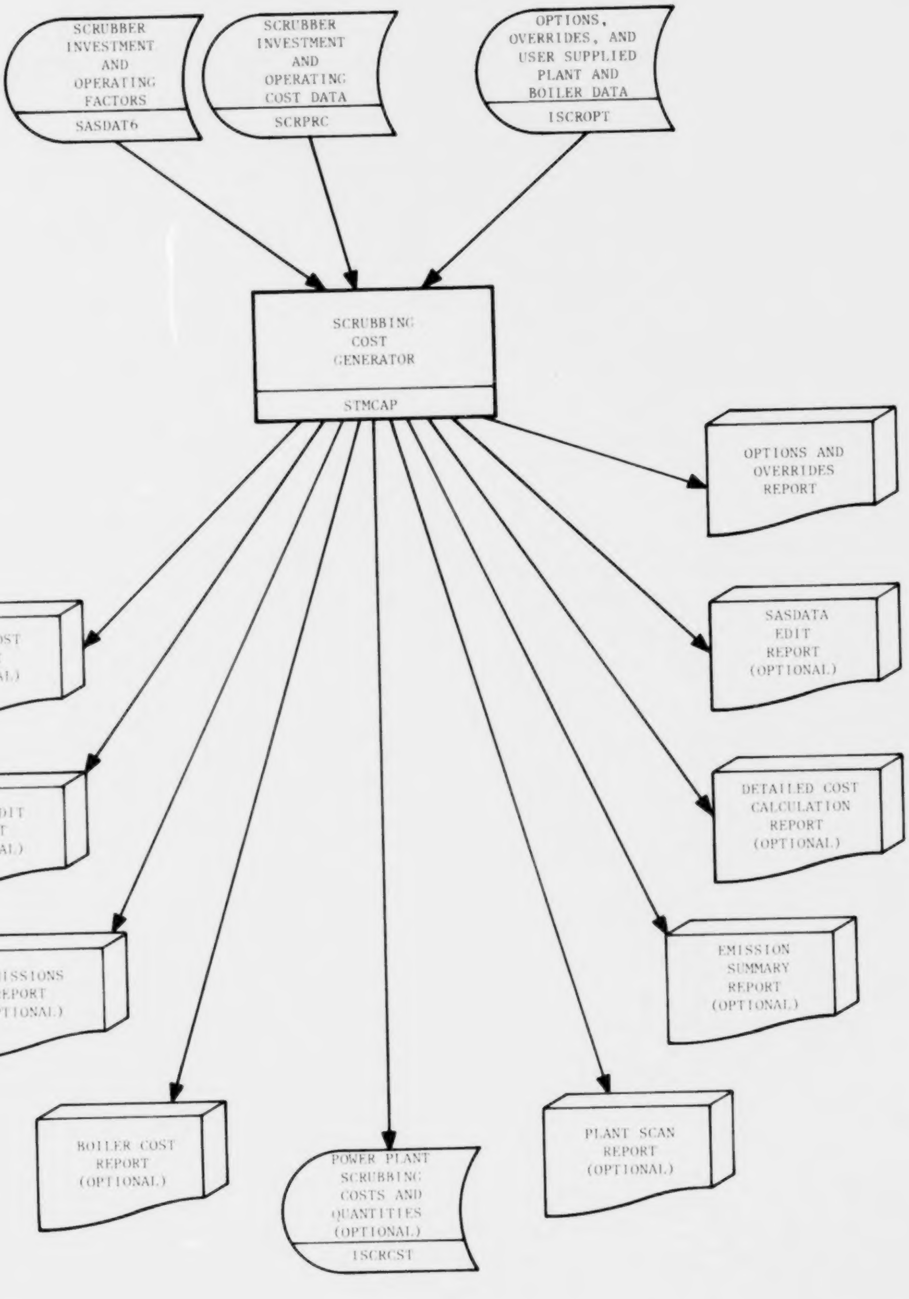

SCRUBBER INVESTMENT AND OPERATING FACTORS
SASDAT6
SCRUBBER INVESTMENT AND OPERATING COST DATA
SCRPRC
OPTIONS, OVERRIDES, AND USER SUPPLIED PLANT AND BOILER DATA
ISCROPT
SCRUBBING COST GENERATOR
STMCAP
OPTIONS AND OVERRIDES REPORT
PLANT COST REPORT (OPTIONAL)
SASDATA EDIT REPORT (OPTIONAL)
INPUT EDIT REPORT (OPTIONAL)
DETAILED COST CALCULATION REPORT (OPTIONAL)
EMISSIONS REPORT (OPTIONAL)
EMISSION SUMMARY REPORT (OPTIONAL)
BOILER COST REPORT (OPTIONAL)
POWER PLANT SCRUBBING COSTS AND QUANTITIES (OPTIONAL)
ISCRCST
PLANT SCAN REPORT (OPTIONAL)

Figure III-4. Block diagram for the calculation of power plant scrubbing costs independently of the overall system (program STMCAP).

only when unusual plant conditions would cause significant deviations from the base-case calculations. Site-factor adjustments are normally not used for user-supplied power plant data because the input data will usually reflect any unusual plant characteristics.

Power plant data can be provided in either of two ways. If program execution is a part of the supply subsystem (Figure III-3) the input power plant data will typically be the output from the projection program (which uses the power plant data base) and the program that adds limestone costs. If execution is independent of the supply subsystem (Figure III-4) the input power plant data will be provided by the user.

General Processing

The minimum output from the program is the options and override report; any other output must be specified using the option specifications. If no other output is specified none is generated so program execution without at least one optional output specification is meaningless.

The options are the first data processed by the program, immediately followed by the processing of some of the overrides. The overrides can be functionally grouped into three categories. The first category is made up of overrides for internal program constants and tables; the second category consists of overrides to the independent file of scrubbing cost data; and the third category consists of overrides for the independent investment and operating factors. Although all of the overrides are optional, there is such a wide variation in the requirements for individual program execution that some of the internal program values almost always require overrides. The scrubbing investment and operating factors and cost overrides are not necessary in many cases.

The conceptualized program flow can be generally described as follows: program control options are processed; any specified overrides to the internal program constants and tables are processed; the independent cost data along with any specified overrides to the cost data are processed; the independent investment and operating factors along with any overrides specified are processed and an internal file for using this data later in the program is generated; and finally the power plant data and any site-specific data values are processed (site-specific data do not apply if power plant data are user supplied). Concurrently with all of the above, specified output data files and reports are generated.

For input processing all of the input data are assigned to a fixed unit number (or file) except for the cost overrides, investment and operating factor overrides, and the power plant data (if user supplied). The unit number (TAPE5 for example) to be read for these three data inputs may be controlled by the user by means of the options. For output data the only fixed unit (or file) assignments are the scrubbing cost output file that will typically be used as input to the transportation and linear programing subsystems and the option and override report (overrides to internal program constants and table values only). All other output, including the reports resulting from the other categories of overrides, may be controlled by the user by means of the options specified. The only limitation on output report control is the number of units provided in the current version of the program. Four separate unit numbers for reports are provided, when a greater number of reports is required some of them must be combined on the same unit. Program changes can be made in special cases to increase the number of output units but this will increase program size and processing costs.

The following detailed description of the options is based upon the current version of the scrubbing cost generator program and, as is the case when general documentation cannot be kept independent of detailed program coding, program modifications may cause exceptions to the documented procedures. Although program changes that alter the execution procedures are not now planned they could be required sometime in the future. If this occurs, any changes to the documented instructions for program processing will be listed when the program is executed so that required adjustments to previous usage procedures can be made.

Options

The options to control the scrubbing cost generator program are always read from the standard input file and must be provided in NAMELIST format. (NAMELIST is described in the FORTRAN manual listed in Appendix B.) The internal program variable name of each option, an abbreviated description of each, the default value, and the user-supplied values are always written immediately to the standard output print file. After reading and listing the options, the overrides of the internal program constants and table values are read from the standard input file. The variable names, along with their default values and the user-supplied values, are immediately written to the standard output print file. The above steps are independent of any options specified.

After the steps just described are executed the specified options control program processing. As shown in Table III-1, up to 16 options are provided. Some of these options are mutually exclusive while others are mutually inclusive. Except for the IN, IO, and KSTOP options they are all initially set to zero and the particular processing step controlled by each option is omitted unless an appropriate nonzero value is specified. The usage sections and the sample output reports should be referred to for more details. The option names, descriptions, and acceptable values of each are as follows:

The IN option specifies the unit number that cost data overrides (KPRICE option), investment and operating data overrides (KSAS option), and user-supplied power plant data (KSIM option) will be read from. If none of these three options are provided, the unit specified by the IN option will not be read. The default value is the standard input file and no other unit number is provided. If the standard input file is unsatisfactory a program change must be made to specify the desired unit number.

TABLE III-1. SCRUBBING COST GENERATOR (STMCAP) PROGRAM EXECUTION OPTIONS

Option name	Description
IN	Controls the unit number that is read for overrides and user-supplied power plant data
IO	Controls the unit number used for reporting overrides, investment and operating data, detailed cost calculations, and power plant data editing results
KSIM	Controls the source of power plant data to be used (either user supplied or from the data base)
KCHECK	Controls the generation of a detailed scrubbing cost report based on user-supplied power plant data
KOFF	Forces offsite ponding calculations (not used during normal execution)
KSCAN	Controls the generation of a one-line summary for each plant
KEMISS	Controls the generation of an emissions report for each plant
KCOSTLP	Controls the generation of both the scrubbing cost file used in the linear programing subsystem and a compliance cost summary report for each plant
KCOSTP	Controls the generation of a compliance cost summary report for each plant
KPRICE	Controls the reading of overrides for the independent scrubbing cost data
KSAS	Controls the reading of overrides for the scrubbing investment and operating factors
LSAS	Controls the generation of a report of the complete files of investment and operating factors and investment and operating cost data
KEDIT	Controls continued program execution after the LSAS option above has been processed
LCP	Controls the generation of a detailed scrubbing cost report based on data base power plant data
KSTART	Specifies the beginning number of power plants that will be processed from the data base
KSTOP	Specifies the ending number of power plants that will be processed from the data base

The IO option specifies the unit number that a listing of cost data overrides (KPRICE option), investment and operating data overrides (KSAS option), the investment and operating data (LSAS option), detailed cost calculation results (KCHECK option), and the power plant data edit listing (KSIM option) will be written to. The default value is the standard print file. Unless the indicated options are nonzero, no output will be generated on the unit specified by the IO option except for the power plant data which are listed regardless of the KSIM option. The allowable units are 6, 20, 30, or 40; a unit of zero can be supplied if none of the listings are required.

The KSIM option controls the source of power plant data to be used by the program. If KSIM is set to zero the output from the projection and add limestone cost programs will be read, the site-factor file (if provided) will be read, and the KCHECK option will be ignored. If KSIM is not zero, user-supplied power plant input data will be read from the unit specified by the IN option, the site-factor file is ignored, and the KCHECK option will be processed if specified.

The KCHECK option is used only when KSIM is not equal to zero; i.e., user-supplied input power plant data are processed from the unit specified by the IN option. Selection of this option by specifying a nonzero value results in the generation of a detailed cost report written to the unit specified by the IO option. (This option is the counterpart of the LCP option for the plant and boiler data from previous subsystem program execution and is described later.) The IPROC variable specifies the process code for which the detailed report will be written and must be supplied along with other user data if the KCHECK option is used. In general, the KCHECK option is only useful during program and cost data modification analysis and must be used carefully; it can result in large volumes of output data for printing.

The KOFF option forces a program analysis of offsite ponding and is not generally used. In normal usage, the distance to the pond (either user supplied or from the data base) automatically controls the calculation of offsite ponding costs.

The KSCAN option is used to provide a quick-look summary report consisting of a one-line entry for each plant processed by the program. The one-line entry contains information such as plant number; plant name; SPLC; number of boilers; whether or not the plant was calculated to be in or out of compliance; a flag for any type of data exception found during processing--such as regulation, fuel, or operating data; an offsite ponding indicator; and the number of boilers scrubbed to meet emission limits (if out of compliance). The allowable values for KSCAN are zero if no report is required or the unit number that the report will be written to, which may be 6, 20, 30, or 40. A one-page emission and abatement summary for all plants combined is also generated as a result of the KSCAN option.

The KEMISS option controls the writing of the emission report for each power plant processed. The allowable values for KEMISS are zero if no report is required or the unit number that the report is to be written to, which can be 6, 20, 30, or 40.

The KCOSTLP option controls the writing of both the scrubbing cost output file that is typically input to the transportation and linear programing subsystems and a report of the scrubbing costs on a boiler-by-boiler basis. If the KCOSTLP option is not specified then the KCOSTP option (see later options) is ignored. The generation of a scrubbing cost data file and the scrubbing cost report cannot be specified independently. The allowable values are zero if neither the scrubbing cost file nor scrubbing cost report is required or the unit number that the report is to be written to, which can be 6, 20, 30, or 40. The unit that the scrubbing cost file is written to is fixed.

The KCOSTP option controls the writing of the compliance cost summary report for each power plant calculated to be out of compliance including costs and quantities of the byproduct produced for each process. In order for this option to apply the KCOSTLP option above must be nonzero or the KCOSTP option is ignored. The allowable values are zero if no compliance cost summary report by plant is required or the unit number that the report is to be written to, which can be 6, 20, 30, or 40.

The KPRICE option controls the reading of overrides to the independent scrubbing cost data file. If the KPRICE option is nonzero, then after the cost data for the specified year is read, user overrides are read from the unit specified by the IN option. They are applied to the appropriate cost values and are listed on the unit specified by the IO option. Allowable values are zero if no overrides to the cost data file are required or a nonzero value if overrides have been provided on unit IN.

The KSAS option controls the reading of overrides to the external file of investment and operating factors. If the KSAS option is nonzero, then as the investment and operating factors file is read the file specified by the IN option above is also read and the overrides found are applied to the appropriate data records and listed on the unit specified by the IO option. Allowable values are zero if no overrides to the investment and operating factors are required or a nonzero value if overrides have been provided on unit IN.

The LSAS option controls the writing of a report of the complete files of investment and operating factors and costs and is independent of the KSAS option above. The file is listed on the unit specified by the IO option. This option is not normally selected since the KSAS option provides for listing modifications and a complete listing of all the factors is not a usual requirement. Allowable values are zero if a complete file listing is not required or a nonzero value if a report of all factors is to be written to the unit specified by the IO option.

The KEDIT option is usually used in conjunction with either the KSAS or LSAS option above. When the KEDIT option is specified, a program stop occurs immediately after processing the investment and operating factors. The option is useful primarily for analysis and editing because the format used in the program to write the file is more descriptive than a direct copy of the data file and the cost data are also included. When this option is specified the only other options honored are IN, IO, KSAS, LSAS, and KPRICE, but the overrides specified by KPRICE will simply be read and listed; no calculations will be made. Allowable values are zero if no program stop is required or a nonzero value if a program stop is to occur after listing the data; i.e., the program execution is merely to list part (KSAS) or all (LSAS) of the investment and operating data and no other processing is to be done.

The LCP option controls the writing of a detailed cost report when power plant input data are from the projection and add limestone cost programs; i.e., KSIM above equals zero. It is the counterpart of the KCHECK option discussed previously, and the same precautions discussed for the KCHECK option apply to the LCP option. Allowable values are zero if no report is required or a nonzero value (typically 6) if a detailed cost report is to be written to the unit specified by the IO option.

The KSTART option is used to limit the processing of power plants from the projection and add limestone cost programs (KSIM equal zero). The value of KSTART should be the FPC number of the plant with which processing is to begin. All plants with FPC numbers less than KSTART will not be considered by the program. Allowable values are zero if no limits are to be placed on the plants or if limited processing is required the appropriate FPC number is specified.

The KSTOP option is the ending FPC number for the same requirement as KSTART. Allowable values are 9999999999 if no limits are to be placed on the plants or the appropriate FPC number when limited processing is required. The plant number given for KSTOP will be included in the processing.

This completes the documentation of the options. As previously discussed the default options and an abbreviated description of each will be written to the standard print file, immediately followed by a listing of the user options that were specified.

Overrides for Internal Program Values

After the options have been processed the next step is the processing of the overrides for the internal program constants and table values shown in Table III-2. Reference to *Detailed Cost Estimates* is mandatory for the use of this category of overrides. In the same manner as the options, the default values of the program constants and table values will be written to the standard print file, immediately followed by a listing of the user overrides that were specified. These overrides are in NAMELIST format and will be read from the standard input file.

TABLE III-2. SCRUBBING COST GENERATOR (STMCAP)

INTERNAL PROGRAM VALUE OVERRIDES

Override name	Description
OPYEAR	Specifies the year for which calculations will be made
CEINDX	*Chemical Engineering* index for scaling investment costs
RATE	Used for calculating the capital charges portion of indirect costs
START	Allowance for startup, modifications, and interest during construction
INTYPE	Plant overhead portion of indirect costs
MAIN	Maintenance rate
INDR	Indirect investment costs
NACOST	Sodium sulfate credit
RETRO	Retrofit difficulty factor
FLOCAT	Location factor adjustment
CONS	Capital investment related to construction costs not covered in other categories
PREMIS	Technology relativity factor
GRACE	Compliance allowance factor
SITEFAC	Site-factor adjustment

The OPYEAR override specifies the year for which calculations will be made. Specification of a given year implies that costs for the various areas of scrubbing have been provided in the independent cost file. The value of OPYEAR is used to search the cost file for a matching value. If no cost record is found for the specified OPYEAR value a program stop occurs.

The CEINDX override is the *Chemical Engineering* index used to scale investment costs associated with the various processes.

The RATE override is used in computations related to the capital charges portion of indirect costs and has two values associated with it. The first value is for new installations and the second value is for existing installations. Tables 59 and 60 on pages 134 and 135 of *Detailed Cost Estimates* show sample average capital charges as a part of the area contribution analysis if the base-case summary includes data for new installations.

The START override specifies the allowance for startup, modifications, and interest during construction. It has six values, one for each of the six processes included in the program design. Pages 27, 88, and 89 of the *Detailed Cost Estimates* should be referred to for sample values.

The INTYPE override specifies the plant overhead portion of indirect costs. Just as for the START override there are six values associated with it, one for each of the six processes. Table 59 on page 134 of the *Detailed Cost Estimates* should be referred to for sample values.

The MAIN override specifies the maintenance rate. One value for each of the six processes is provided. Table 13 on page 29 and Table 59 on page 134 of the *Detailed Cost Estimates* should be referred to for sample values.

The INDR override specifies the indirect investment costs. This override has 12 values. The first six values apply to new installations for each of the six processes and the other six apply to existing installations for each of the six processes. Table 10 on page 27 and Tables 35 and 36 on pages 88 and 89 of the *Detailed Cost Estimates* should be referred to for sample values.

The NACOST override specifies the rate per ton of sodium sulfate that will be applied as a credit against the costs of the sodium process.

The RETRO override specifies the retrofit difficulty factor that will be applied. Power plants in the data base have a PEDCo retrofit difficulty factor specified where available. The primary reason for the RETRO override is for application to user-supplied data.

The FLOCAT override specifies any location factors that are significantly different from the base cases. It is normally set to one, particularly when processing all of the plants from the data base. It is most typically used when user-provided power plant data are processed and known location factors show that adjustments to the base-case data should be made. Functionally it can be related to the site-specific factors that can be applied to power plant data from the projection program except that the FLOCAT factor can be applied regardless of the source of power plant data.

The CONS override specifies the percentage of total capital investment that is related to construction costs not specifically covered in the other capital investment categories. Table 35 on page 88 of the *Detailed Cost Estimates* should be referred to for sample values.

The PREMIS override is a technology relativity factor. It allows technology changes to be taken into account in the year for which calculations will be made, relative to the base year used in *Detailed Cost Estimates* (the base case is assumed to have a process premise factor of 1.0). There are six PREMIS values, one for each of the processes. They are applied uniformly to all plants independently of the scrubbing investment and operating cost data.

The GRACE override is a compliance allowance factor. During the conversion of regulations to a lb SO_2/MBtu basis and the calculation of both actual and allowed emissions on a tons of sulfur per year basis, various rounding differences occur. The GRACE override allows these differences to be taken into account rather than considering a plant out of compliance on the basis of small differences between actual and allowed emission levels.

The SITEFAC override provides for site-specific factors that differ from the base-case assumptions. It is applied uniformly to all plants rather than to specific plants, which is the case of site factors provided in the site-factor adjustment file. It is provided primarily for user-supplied data, but it is not typically used because the actual data normally reflect any exceptions to the base case. Up to six site factors may be provided, one for each process.

The overrides of the internal program constants and table values complete the basic requirements for running the scrubbing cost generator program. All of the options and overrides just presented will not be required for each execution of the program. Most runs will probably be relatively straightforward and can use the results of the base-case calculations and the associated scaling factors. The options and overrides are provided because data file updating and program modification for only slightly different run requirements can consume more resources than actual program execution. Dynamic run time modification allows a wide variety of processing requirements to be honored and at the same time preserves the base-case input data and a standard version of the program. This reduces the indirect costs associated with program usage and allows many program executions to be made in a shorter time. This can be significant when several runs are made to analyze the cost difference that results from varying the possible combinations of fuel and operating characteristics for a power plant (such as heat and sulfur content of the fuel, boiler capacity factors and heat rates, overrides to the base-case calculations and the associated scaling factors, etc.).

The preceding program documentation, the section on program usage where sample setups for execution are described, and the file and records sections which describe input data formats and sample output listings of results should be examined in detail before actual program execution is attempted. If the program processing procedures, input requirements, and possible output results are not clear after a review of all of the sections described previously, a source program listing can be referred to or trial and error procedures may be useful if problems are very minor.

ACDUPDT PROGRAM

The purpose of the ACDUPDT program (Figure III-5) is to determine transportation rates for the shipment of molten sulfur from Port Sulphur to each sulfuric acid plant. These rates are used in a subsequent program as a part of the data required to calculate avoidable acid production costs. Four input files are required for program execution--all provided independently rather than being generated by a program in the system. These files are the acid plant and smelter data file that contains information about plant location and operating characteristics, the sulfur terminal data file that contains information about the location and rates associated with each barge terminal used in the water transportation of molten sulfur from Port Sulphur, the rail mileage file that contains the distance between any given source and destination rate basing points, and the sulfur tariff file that contains the rates for shipping sulfur by rail. Only acid plants east of the Rocky Mountains have sulfur transportation rates calculated. Rail rates used in the system are limited to the Docket 28300 area. Transportation rate calculations are further limited to acid plants that burn elemental sulfur as the feedstock. The plant status code allows the determination of both of these qualifications (see section IV).

To determine the transportation rates for molten sulfur from Port Sulphur to a given acid plant the appropriate barge terminal must be found. The distance from the acid plant to all barge terminals is determined by accessing the rail mileage file using the rate basing point of the acid plant and the rate basing points of the terminals. These distances are used to access the sulfur tariff file and the rail shipping rates are determined. The terminal is selected that results in the lowest total transportation costs for each acid plant. Total rates from Port Sulphur to each acid plant through any terminal can be calculated because each terminal record contains the necessary barge rate information for that terminal. The total rate is the sum of the barge rate from Port Sulphur to the terminal, the terminal handling charges associated with the transfer of the molten sulfur from barge to rail (including intermediate storage charges where applicable), and the rail rate from the terminal to the acid plant (if applicable).

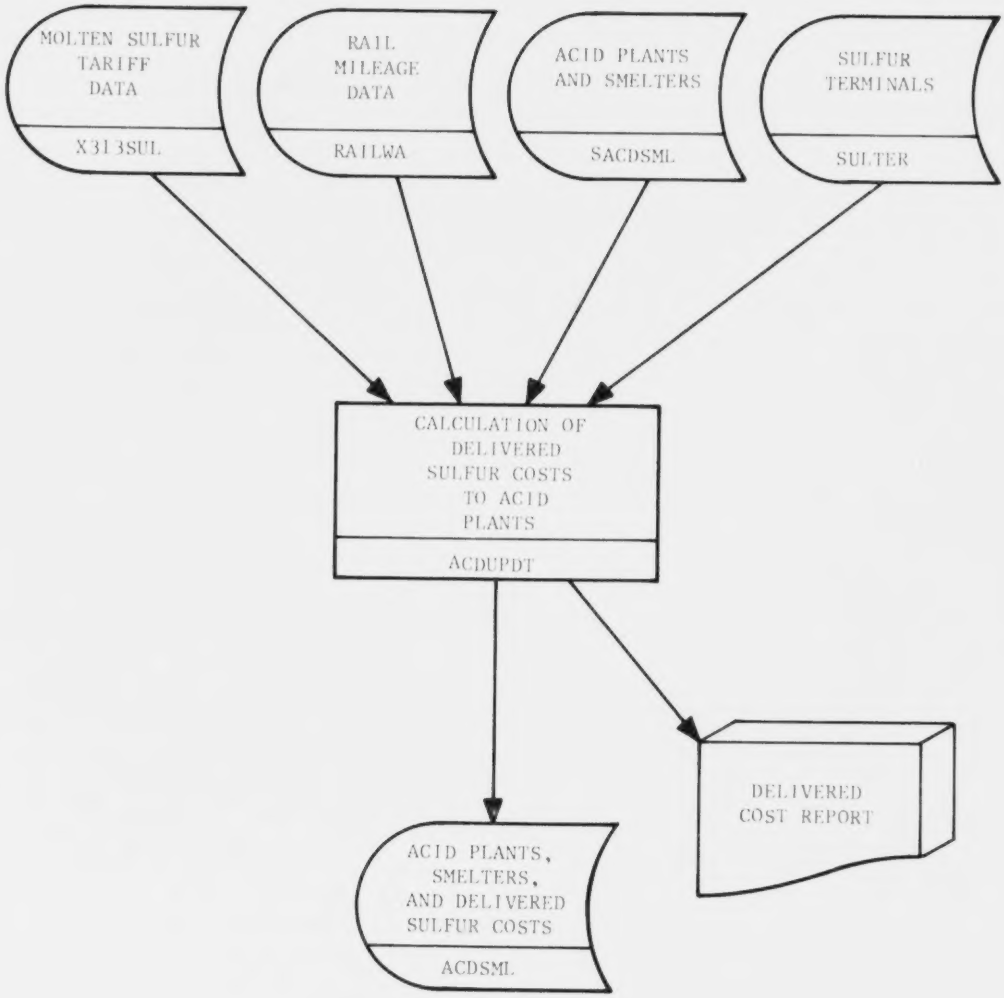

MOLTEN SULFUR TARIFF DATA
X313SUL
RAIL MILEAGE DATA
RAILWA
ACID PLANTS AND SMELTERS
SACDSML
SULFUR TERMINALS
SULTER
CALCULATION OF DELIVERED SULFUR COSTS TO ACID PLANTS
ACDUPDT
ACID PLANTS, SMELTERS, AND DELIVERED SULFUR COSTS
ACDSML
DELIVERED COST REPORT

Figure III-5. Block diagram for the calculation of delivered sulfur costs to acid plants (program ACDUPDT).

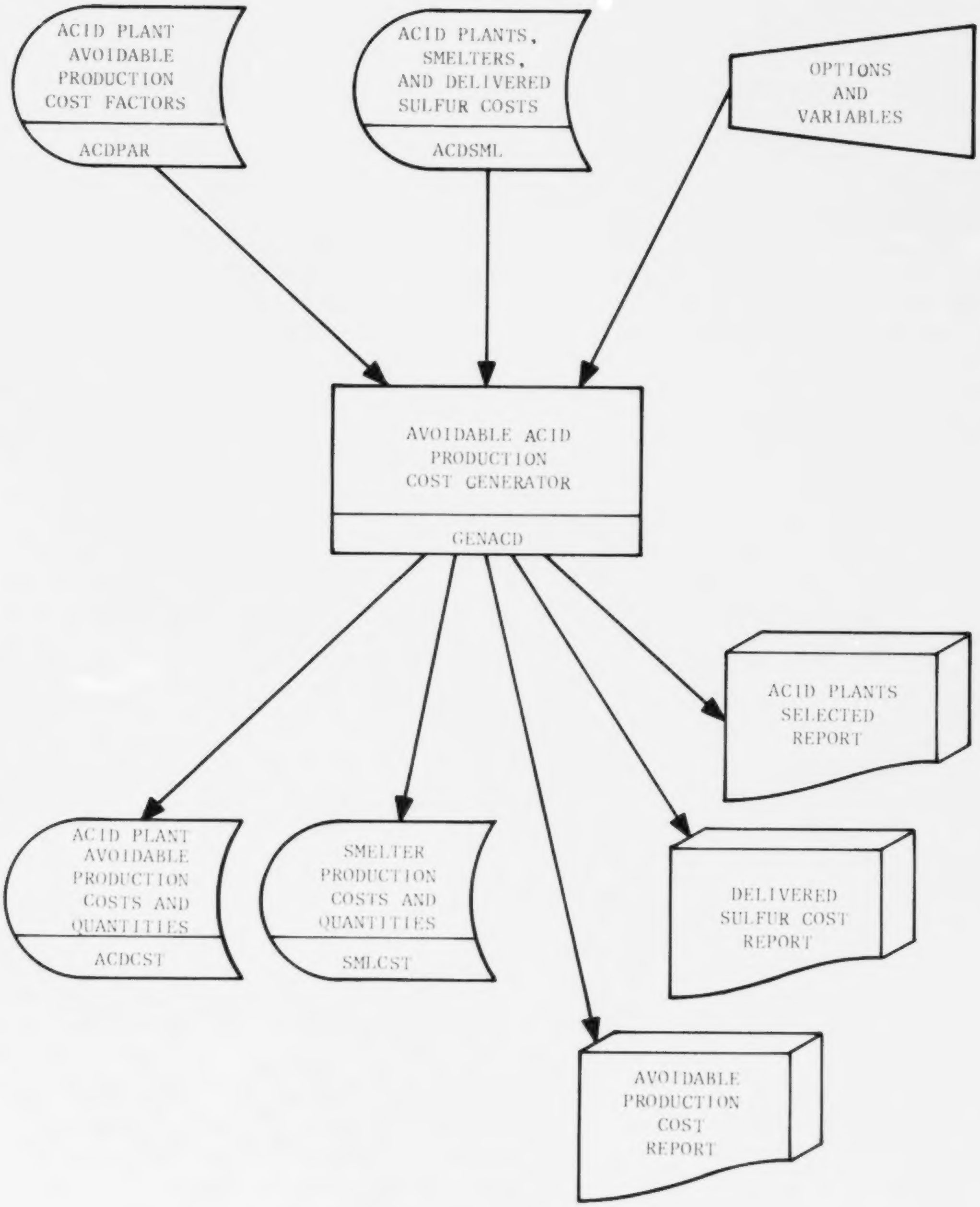
The output from the program is an updated acid plant file with the sulfur transportation data added and a report that includes the terminal selected and the total transportation rate for each acid plant. The updated acid plant file is in the same format as the input file; new information is inserted into fields that were already provided. The added data include the terminal selected, the barge rate from Port Sulphur to the terminal, terminal handling charges, rail rates from the terminal to the acid plant, and the total rate. The output report that is generated is written to the standard print file.

GENACD PROGRAM

The GENACD program (Figure III-6) calculates an avoidable unit production cost for each of the sulfuric acid plants to be considered as a potential demand point for byproduct acid. The input to the program consists of the acid plant data file (output from the ACDUPDT program), the independent avoidable production cost file, and output report selection specifications. Output from the program is a smelter file, an acid plant file that includes avoidable production cost estimates, and up to three reports depending upon the report specifications provided. The input file of acid producers contains two types of plants--those burning elemental sulfur as a feedstock as well as those using smelter off-gas. Because the smelters are not potential demand points of abatement acid but are actually potential suppliers, these two types of producers must be considered separately.

The smelters are processed by calculating a projected estimate of future production increases based upon current capacity and compliance status. Plants out of compliance are projected to have a greater production increase as a result of increased sulfur dioxide removal to meet clean air standards. These projected increases are assigned a zero unit production cost; therefore when they are later combined with the power plants to form the total supply input to the marketing model they will have an advantage over the power plants (which typically have a greater-than-zero incremental production cost). After the projected production increases and unit production costs for the smelters are completed they are written to an output file. The remaining acid plants are then used in avoidable production cost calculations and will be considered as consumers of byproduct acid from both smelters and power plants. To provide maximum flexibility and to minimize program modification and recompilation, the factors used in the calculations are in a sequential data file rather than coded within the program (see section IV).

Avoidable production costs are calculated for the acid plants remaining in the original input file and an acid plant avoidable production cost output file is written. Up to three reports may be selected as a result of program execution: (1) a report of the acid plants considered, (2) a report of the sulfur transportation charges for each acid plant, and (3) an avoidable production cost report. When the program is executed interactively, the various report options are printed and a user response is made to select the desired reports. All three reports are written to the standard print file.



ACID PLANT AVOIDABLE PRODUCTION COST FACTORS
ACDPAR
ACID PLANTS, SMELTERS, AND DELIVERED SULFUR COSTS
ACDSML
OPTIONS AND VARIABLES
AVOIDABLE ACID PRODUCTION COST GENERATOR
GENACD
ACID PLANTS SELECTED REPORT
ACID PLANT AVOIDABLE PRODUCTION COSTS AND QUANTITIES
ACDCST
SMELTER PRODUCTION COSTS AND QUANTITIES
SMLCST
DELIVERED SULFUR COST REPORT
AVOIDABLE PRODUCTION COST REPORT

Figure III-6. Block diagram for the calculation of acid plant avoidable production costs (program GENACD).

The GENACD program documentation and procedures just described apply only to the automated capabilities of the demand subsystem (those locations in the Docket 28300 area east of the Rocky Mountains) which limit the acid plants and smelters considered to that same area. There is no direct equivalent to the Docket 28300 concept for the western and transcontinental railway systems. A separate run of the program is required for western acid plants and smelters and the data must be handled manually; it cannot be combined directly with the data for the Docket 28300 area.

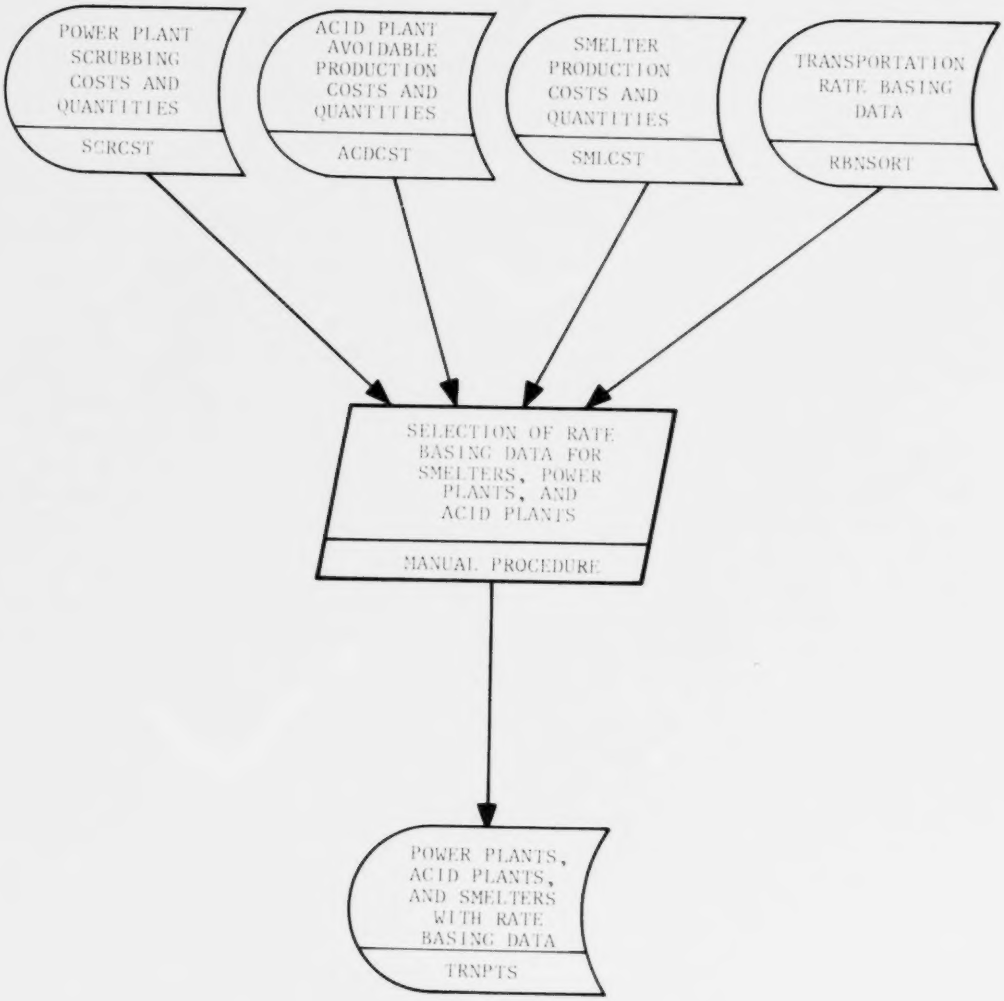
MANUAL TRANSPORTATION PROCEDURE

As previously discussed, an integrated transportation data base was to have been developed so that the transportation cost generation process could be completely automated. This is reflected in the format and description for the TRNPTS file (see section IV and Appendix A). When the final step of linking all rail, barge, and truck points was not completed, the manual procedure shown in Figure III-7 was substituted and transportation rates in the linear programing model were limited to rail shipments within the Docket 28300 area.

Before the linear programing model can be generated, shipping rates must be calculated for every possible combination of supply and demand points that will be considered in the model. This includes power plants, smelters, acid plants, and transshipment terminals for the Western States and Canada. For every possible supply and demand point combination, the location of each point and the distance between them are required. The location is required to select the appropriate tariff table from the tariff file; the distance is required to select the applicable tariff rate from the tariff table (tariff files are described in section IV).

There are four sources of locations that must be used to build the TRNPTS file; three are data files from the supply and demand subsystems. The data files are the power plant scrubbing cost file (SCRCST), the smelter cost file (SMLCST), and the acid plant avoidable production cost file (ACDCST). The fourth source of location data is for the transshipment terminals. The transshipment terminal data are found in the linear programing model generator program (GENPGM) rather than in a previously created data file. A source program listing can be referred to if necessary.

All rail mileages used to determine the applicable rates within the Docket 28300 area are derived using 2632 rate basing points. The required data for these rate basing points are in the RBNSORT file. If the actual rate basing point is not known (which is normally the case), then maps, comparisons between the location SPLC and rate basing point SPLC, and other geographic- and transportation-related data must be used to estimate the applicable rate basing point.



POWER PLANT SCRUBBING COSTS AND QUANTITIES
SCRCST
ACID PLANT AVOIDABLE PRODUCTION COSTS AND QUANTITIES
ACDCST
SMELTER PRODUCTION COSTS AND QUANTITIES
SMLCST
TRANSPORTATION RATE BASING DATA
RBNSORT
SELECTION OF RATE BASING DATA FOR SMELTERS, POWER PLANTS, AND ACID PLANTS
MANUAL PROCEDURE
POWER PLANTS, ACID PLANTS, AND SMELTERS WITH RATE BASING DATA
TRNPTS

Figure III-7. Block diagram for the selection of rate basing data for smelters, power plants, and acid plants (manual procedure).

The actual tariff table and rate selection process is already automated in the TRNCOST program that follows this manual procedure. The TRNPTS file provides all of the necessary data. However, the building of the TRNPTS file is not automated. An automated procedure for building the TRNPTS file could have been developed if the integrated transportation data base had been completed. The locations to be modeled could be determined by examining the four location sources; the rate basing data for any location could be extracted from the data base (the data base contains every U.S. location); and the TRNPTS records could be automatically generated. Instead, the four location sources and the RBNSORT file must be examined manually and the TRNPTS file built manually, record by record, for each location.

Only 5 of the 10 fields in the TRNPTS file (section IV) are actually used: the location identification code; the location SPLC; the rate basing point SPLC; the rate basing point number (rail mileage index); and the tariff table index. Once the rate basing point number is found for a location, a TRNPTS record can be built. The identification code and SPLC from the appropriate location source file are combined with the rate basing point SPLC, the rate basing point number, and the tariff table index from the RBNSORT file to form a TRNPTS record.

The TRNPTS file is divided into two sections. The first section contains all demand locations, the second section contains all supply locations. A special record with an all-zero identification code is used to separate the sections. Transshipment terminals are included in the supply section because previous analyses of the western and Canadian supply-demand have indicated a potential excess supply from these locations, not a demand. In the demand section the records should be in sequence by the acid plant identification code. In the supply section the records should be grouped by power plant, smelter, and transshipment terminals, and within each group the records should be in sequence by the respective identification codes. (The codes were originally assigned so that the correct grouping will occur in the supply section if the records are in sequence by the identification codes.)

As the TRNPTS file is processed by the TRNCOST program, rates are calculated for every possible combination of supply and demand locations in the file. There is no edit check to determine whether the locations are necessary for the model or if the identification codes are correct, so the identification codes must be entered exactly as found in the four location sources. In the TRNCOST program these codes are used as keys to build the transportation cost file (TRNCST). At model generation time (program GENPGM) the identification codes of the locations required for the model are used as access keys into the TRNCST file. Any unnecessary rates are ignored but a missing rate resulting from either an omitted location or an incorrect identification code in the original TRNPTS file will cause model generation to abort.

All acid plants, smelters, and transshipment terminals are typically included in every model (presently about 100 acid plants, 15 smelters, and 10 transshipment terminals). The number of power plants included is a function of the ACFL and the number of plants in the SCRCST file (the SCRCST file contains only the plants for which scrubbing costs were calculated). The SCRCST file never contains all plants in the data base and in general all plants in the SCRCST file are not included in a single model (presently the data base contains about 1000 power plants; the SCRCST file has not exceeded 200 plants; the number of plants included in a model has not exceeded 60).

In a totally automated transportation system, it is conceivable that all power plants might be included in the TRNPTS file even though all plants would never be included in a single model. The advantage would be that once rates are calculated for all possible combinations, no further runs of the transportation cost generator would be required until new locations are added or tariffs are updated. Model runs could include any power plant in the data base and the necessary rates would already be in the TRNCST file. The controlling factor for including potentially unnecessary locations in the TRNPTS file is the cost of calculating rates for these locations in the TRNCOST program.

The transportation system is not completely automated, however, and a controlling factor is also the time required to manually examine the locations, determine the rate basing points, and build the TRNPTS records. To determine the number of power plants that will be included in a given model and reduce the TRNPTS power plant records to that number, the ACFL value to be used can be compared to the limestone scrubbing costs (cents/MBtu) in the scrubbing cost file (SCRCST).

In normal use of the system, the TRNPTS file is rarely created in its entirety; it is merely updated from one model run to the next. The only changes typically required are to add and remove power plant records. All of the preceding procedures still apply except that the new records must be inserted among the existing records based on identification code so that the correct sequence is maintained.

TRNCOST PROGRAM

The TRNCOST program (Figure III-8) calculates rail freight rates for all possible combinations of suppliers (eastern power plants and smelters, western and Canadian producers through transshipment terminals) and consumers (eastern acid plants). Program inputs consist of the TRNPTS file of rate basing data (created by the manual procedure) for all suppliers and consumers to be considered in the marketing model, the independent rail mileage data file, and the independent file of tariff tables. Program output includes a data file of rail rates for all possible combinations of suppliers and consumers, and a report of information related to the calculation of the rail rates.

Determination of rates for every possible combination of supply and demand points is done on a supply point basis. The TRNPTS file contains all locations to be considered, separated into supply and demand. For each potential supply location rail rates are developed from that supply

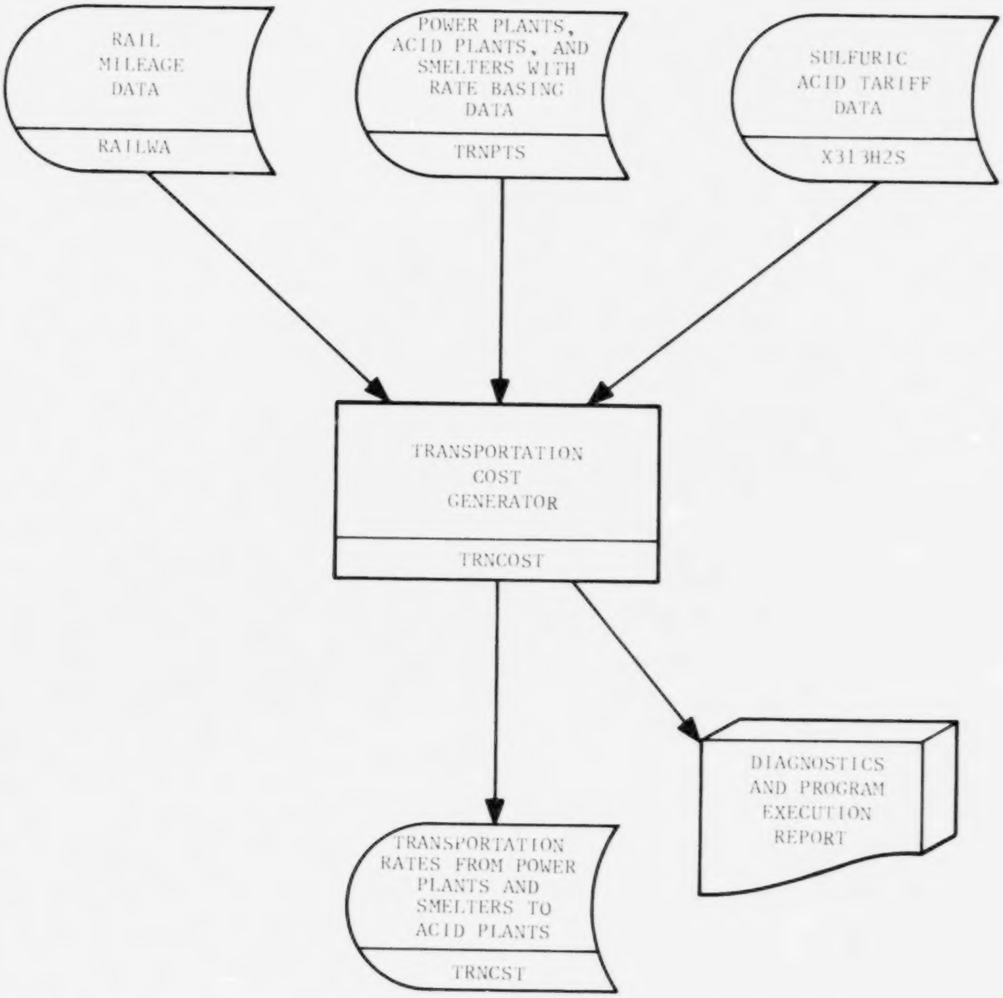

RAIL MILEAGE DATA
RAILWA
POWER PLANTS, ACID PLANTS, AND SMELTERS WITH RATE BASING DATA
TRNPTS
SULFURIC ACID TARIFF DATA
X313H2S
TRANSPORTATION COST GENERATOR
TRNCOST
DIAGNOSTICS AND PROGRAM EXECUTION REPORT
TRANSPORTATION RATES FROM POWER PLANTS AND SMELTERS TO ACID PLANTS
TRNCST

Figure III-8. Block diagram for calculation of transportation rates from power plants and smelters to acid plants (program TRNCOST).

point to all demand points. The current program version provides rate entries for 200 demand points per supply point in the TRNCST output file used in the marketing model. The procedure for creating the TRNCST file can be described as follows:

1. The rate basing points and tariff table indices of all demand locations are taken from the demand section of the TRNPTS file.

2. The rate basing point and tariff table index of the first supply location is taken from the supply section of the TRNPTS file.

3. The rail mileage between the supply location from step 2 and each demand location from step 1 is obtained using each pair of locations as source and destination points to access the rail mileage file.

4. The rail mileage values from step 3 and the tariff table indices from steps 1 and 2 are used to select the appropriate tariff table (using the indices) and the rate entry within the table (using the mileage).

5. For each pair of supply-demand points in steps 1-4, an entry in the TRNCST record is built that contains the tariff table index of the supply point, the tariff table index of the demand point, the tariff table number used, the rail mileage between the supply and demand points, and the rail rate to be used in the model. For each supply point, up to 200 of these entries per record are built, one entry for each demand point (the TRNCST record contains 200 entries but the number of entries with valid rate data depends on the number of demand points in the TRNPTS file).

6. Steps 2-5 are repeated for each supply record in the TRNPTS file.

The sulfuric acid tariff file contains tables that are based upon the various tariff rates that apply depending upon the source and destinations of shipments. The RBNSORT file that was used to build TRNPTS records has tariff table indices that correspond to the various rate basing points and were a part of the data included in the TRNPTS file. A tariff table selection matrix is coded as a part of the TRNCOST program so that the supply point tariff index and demand point tariff index can be used as subscripts into the tariff table selection matrix (or array) where the tariff table number that applies is stored. When the table number is known the rate within that table depends only upon the distance to be shipped.

The TRNCST file is written as a random file. The supply point identification code is used as the key at file creation time. The data are retrieved in the model generation program (GENPGM) by a random read of the file with the appropriate supply point identification code as a key.

The TRNCOST program execution can be generally summarized by the following: For each supply point - demand point combination of locations in the TRNPTS file, the rail mileage between each pair of points is found from the RAILWA file using the rate basing numbers of each point; the applicable rail rate for potential shipments between each pair of points is found from the tariff file using the tariff table indices from the TRNPTS file and the rail mileage; and finally, a random data file is written, one record per supply point with rate entries for up to 200 demand points per record.

GENPGM PROGRAM

The GENPGM program (Figure III-9), the first program in the linear programing marketing model subsystem, generates the model to be solved by the APEX linear programing package. All preparation and processing of data to be used in the model must either have been completed before the execution of this program or must be done during program execution before the model is generated. There are no provisions for changing the model once it is built. The data from the other subsystems (SCRCST, SMLCST, ACDCST, and TRNCST files) discussed previously should have already been prepared and ready for use in the model.

As previously discussed in the system and subsystem sections, power plant byproduct acid is assumed to replace existing supply, not add to it. Based upon this assumption, total demand will be unaffected by power plant compliance strategies, so the total potential demand is included in all models. In addition, potential production increases by current suppliers of byproduct acid (eastern smelters and the net supply from the West and Canada) are assumed to be unaffected by power plant compliance strategies, so projected production increases by current suppliers are also included in all models. The only data that remain to be included in the model are the power plant data, costs for the alternative clean fuel level (ACFL) that will be used, and the option that determines how the ACFL will be used.

There are many assessments and interpretations of the conditions that influence or directly contribute to the total cost of a clean fuel strategy. In many cases projections of future ACFL costs may be more appropriate than current costs and several separate model runs may be required to analyze the overall effects that result from variations in ACFL. Because of this, and to provide maximum user flexibility, the ACFL used in the strategy selection process, including the generation of a model, is a user-supplied condition. Because related cost calculations in the system are on a cents/MBtu basis, the ACFL must also be in cents/MBtu. The ACFL is not limited to any particular clean fuel strategy; it may be total use of naturally occurring lower sulfur fuel, coal washing, fuel blending, etc., but in any case the increased costs that would result from implementing a clean fuel strategy can be calculated in terms of cents/MBtu and provided as the ACFL value.

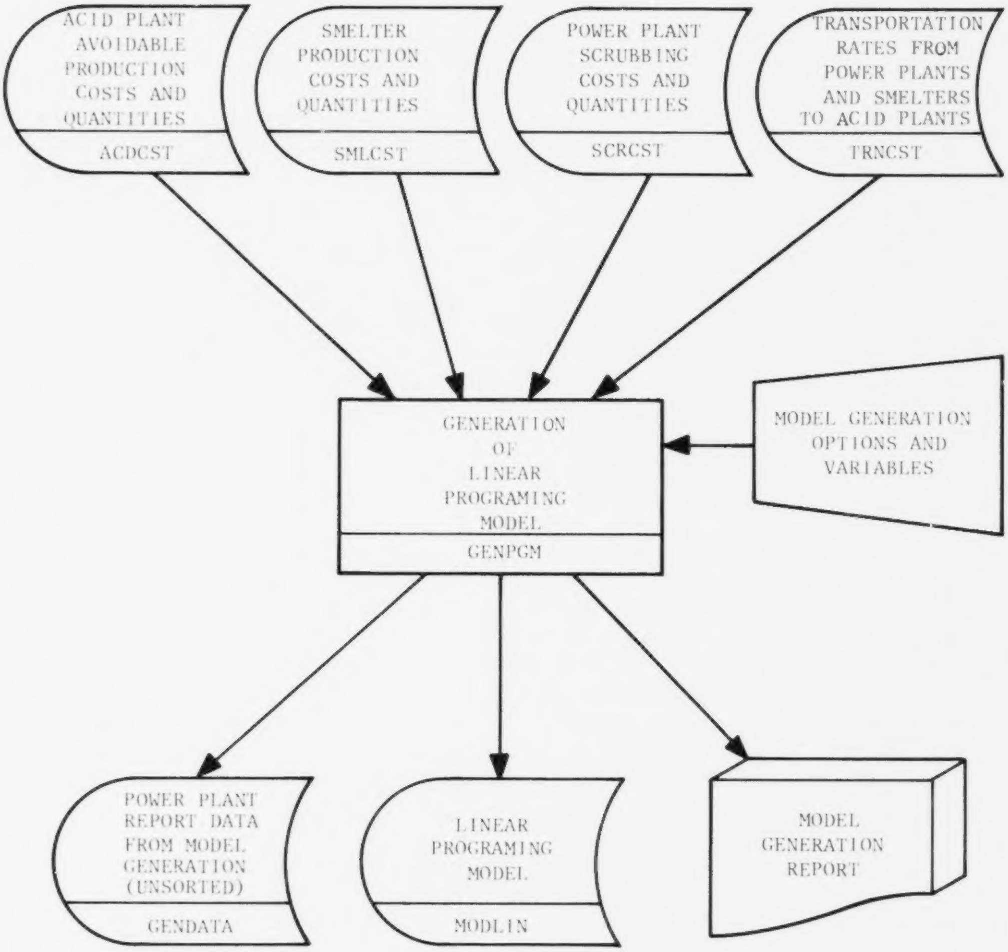

ACID PLANT AVOIDABLE PRODUCTION COSTS AND QUANTITIES
ACDCST
SMELTER PRODUCTION COSTS AND QUANTITIES
SMLCST
POWER PLANT SCRUBBING COSTS AND QUANTITIES
SCRCST
TRANSPORTATION RATES FROM POWER PLANTS AND SMELTERS TO ACID PLANTS
TRNCST
GENERATION OF LINEAR PROGRAMING MODEL
GENPGM
MODEL GENERATION OPTIONS AND VARIABLES
POWER PLANT REPORT DATA FROM MODEL GENERATION (UNSORTED)
GENDATA
LINEAR PROGRAMING MODEL
MODLIN
MODEL GENERATION REPORT

Figure III-9. Block diagram for the generation of the linear programing marketing model (program GENPGM).

Two options are provided to control the method by which the ACFL will be used in the selection process. In both cases the first step in the program is a comparison of the clean fuel and limestone scrubbing strategies in which the lowest cost strategy is selected. Then, depending on the option, the model will be built based on different comparisons.

If the first option is chosen, all plants in which limestone scrubbing is the lowest cost strategy will go into the model as a comparison of the limestone scrubbing strategy with the byproduct strategy. All plants in which clean fuel is the lower cost strategy will be further compared to determine the incremental cost of the byproduct strategy compared to the clean fuel strategy in terms of acid cost. If the acid cost is less than $30/ton, the plant will go into the model as a comparison of clean fuel strategy with the byproduct strategy. Those plants with an incremental acid production cost of over $30/ton will not go into the model.

The second option, in effect, imposes a clean fuel bias. After comparison of limestone scrubbing and clean fuel, if clean fuel is found to be the lowest cost strategy the plant will not go into the model and no further comparisons of strategies are made. If limestone scrubbing is found to be the lowest cost option the plant will go into the model as a comparison of limestone scrubbing and byproduct strategies. Using this option a direct comparison of the clean fuel strategy and the byproduct strategy is not made.

Both the ACFL cost and the option to control its use have important effects on the type of model generated and thus on the costs of its execution and the nature of its results. In the case of both options, the ACFL is used in one sense as a screening factor which determines the selection of plants to be included in the model. The nature of this screening factor is further determined by the choice of options. The model structures defined by these decisions can differ in the number of plants included and the types of strategies directly compared. This in turn determines the quantities of acid considered for marketing and the transportation network used and therefore the outcome of the equilibrium solution.

An additional assumption is used in the power plant selection process. Power plants with a sulfuric acid producing potential of less than 66,000 tons/yr are assumed too small to be competitive in the market and the only options considered are either a clean fuel or a disposable byproduct strategy.

The preceding description of the power plant selection process has been on a plant basis to avoid complexity but the actual strategy selection procedure is on a boiler-by-boiler basis. The only difference is that combined strategies may result for a single plant. Because it is not probable that a power plant will install two different scrubbing processes, the only strategy combinations allowed are either a clean fuel strategy and a disposable byproduct strategy, or a clean fuel strategy and a marketable byproduct strategy. Where mixed strategies are indicated the division between strategies is always on a discrete boiler-by-boiler basis--a boiler is not split between strategies.

Although the strategy selection process for all plants cannot be completed until the model is solved, plants that would select a clean fuel strategy in any case based upon the ACFL to be used can be preselected and excluded from the model. Plants that would select a disposable byproduct strategy because of size (potential acid production less than 66,000 tons/yr) when a clean fuel strategy is not indicated can also be preselected and excluded from the model. These preselected plants are written to a report file.

There are several problems with modeling the 11 Western States of the transcontinental and mountain Pacific areas and Canada. In the present model these locations cannot be treated on the same basis as the 37 Eastern States of the Docket 28300 area. Shipping rates between points within these areas and between these areas and the locations that must be considered within the Docket 28300 area have been impractical to automate and must be done manually on a case-by-case basis. Because of this a separate manual analysis of the western and Canadian supply-demand is done independently of the transportation cost generator. The results of previous analyses have indicated a potential net supply from these areas.

However, the number of shipping rates required, from net supply locations indicated by the analyses to eastern demand points, has still been excessive (over 1000 rates would have to be developed by hand). Two steps are taken to reduce the number of rates required to consider the effects of a potential supply from the West and Canada in the model solution. First, the potential supply is summarized for each Western State and Canada. Next, assumed transshipment terminal locations are assigned within the 37 Eastern States. This reduces the number of required shipping rates to a more practical level.

Transshipment terminals have been defined and, as a result of including them in the TRNPTS file, shipping rates have been calculated to all potential eastern demand points. Potential western and Canadian supply can now be considered on the same basis as eastern supply points except for one difference. For eastern supply locations, the point of production and the point considered for marketing are the same. The unit production cost is the only factor involved in marketing from that point. For the transshipment terminals there is a second factor, the cost of shipping from the point of production (the Western States and Canada) to the point considered for marketing (the terminals). So that all potential supply can be processed equally, western and Canadian production costs are combined with shipping rates to the terminals. The sum is used as a total production cost at the terminals, the point considered for marketing in the model.

All data for the net western and Canadian supply are coded internally in the model generator program (except for the transportation rates calculated from the TRNPTS file) and included in every model. The transshipment terminal identification code, the terminal "production cost" (actual production costs plus shipping costs to the terminal), the potential supply quantities, and a terminal usage handling charge (also added to terminal production costs) make up the internal program data. During program execution the internal program data and data from the SCRCST, SMLCST, TRNCST, and ACDCST files are combined to build the required model.

The strategy selection process can be summarized by the following statements. For each plant in the SCRCST file, records are read on a boiler-by-boiler basis and the disposable byproduct scrubbing costs, the marketable byproduct scrubbing costs, and the user-supplied ACFL are compared. If the disposable byproduct costs are lowest, the incremental costs of the marketable byproduct strategy are calculated based on a comparison with the disposable byproduct strategy and the potential production and incremental cost are included in the model (if the potential production is less than 66,000 tons/yr a disposable byproduct strategy is preselected). If the ACFL is lowest, the incremental costs of the marketable byproduct strategy are calculated based on a comparison with the ACFL and the potential production and incremental cost are included in the model (if the incremental cost is greater than $30/ton or the potential production is less than 66,000 tons/yr, a clean fuel strategy is preselected). Boiler data are always combined into plant totals for the strategy selected. When a split strategy is indicated, the plant total is divided into two separate totals for the boiler and strategy combination indicated. In all cases where potential suppliers are included in a model the appropriate transportation data from the TRNCST file are also included. When all boilers for all plants have been processed and the model has been built, the next step in the subsystem is the solution of the model using the APEX linear programing package. There are no further user options or modifications in the linear programing marketing model subsystem. The only choice available is either to solve the model and report the results or discard the model generated by the GENPGM program.

The purpose of this manual is to provide the information necessary to use the byproduct marketing system. It is impractical to try to also include all of the linear programing concepts and implications required to create the marketing models. Users who desire detailed information should refer to a source program listing of the GENPGM program or the APEX linear programing manual (see Appendix B).

GENSORT PROCEDURE

The GENSORT procedure (Figure III-10) sorts the power plant data from the GENPGM program so that it can be used in the REPTSOL program to build a report of strategy selection for all plants. Two types of records must be sorted. The first type consists of data for all power plants that were included in the model as potential candidates for a marketable byproduct strategy, the second type is a strategy status

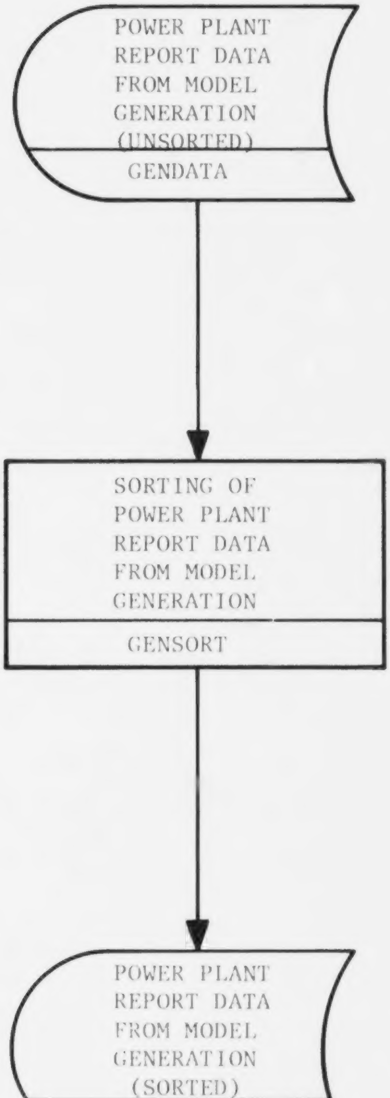

POWER PLANT REPORT DATA FROM MODEL GENERATION (UNSORTED)
GENDATA
SORTING OF POWER PLANT REPORT DATA FROM MODEL GENERATION
GENSORT
POWER PLANT REPORT DATA FROM MODEL GENERATION (SORTED)
GENREPT

Figure III-10. Block diagram for sorting the power plant data from the linear programing model generation (program GENSORT).

record for every plant considered in the strategy selection process by program GENPGM. The record types are separated by a special record of zeroes. The GENDATA and GENREPT record formats in section IV should be referred to if necessary.

APEX SYSTEM

The APEX system (Figure III-11) is basically an optimization system. Its main function is to optimize linear models to either maximize gains or minimize losses. The four major activities involved in handling all linear programing problems have either been previously completed during execution of the programs and procedures in the various subsystems or will be completed when the model is solved. These activities are summarized by the following steps:

1. All of the data that are related to solving the problem is collected and organized into a data base (the data base may simply consist of some logical grouping of the data into one or more data files). Typical information usually includes costs, capacity relationships, transfer combinations, etc.

2. The data from step 1 are transformed into a format that a linear programing system can analyze. The new format is usually referred to as a linear model or an LP model, and a matrix generator program is used to build the model.

3. Once the model is generated it is solved by the linear programing system to produce an answer that is both feasible and optimal.

4. APEX produces a standard set of printed reports to describe the solution but in most cases special customized reports are required. Therefore a binary solution file is also provided to allow maximum flexibility in developing solution results by using a report generator program. The REPTSOL program is the report generator in the byproduct marketing system.

As previously discussed, linear programing knowledge is not required to use the byproduct marketing system. Users who require detailed information should refer to the source program listings of GENPGM, REPTSOL, and an APEX manual (see Appendix B).

Once the model is built by program GENPGM no further options are provided to control the model. The procedure to solve the model and report the results must either be executed or the model must be discarded.

REPTSOL PROGRAM

The REPTSOL program (Figure III-12) generates a report analysis of the model solution. Input to the program consists of the SMLCST, ACDCST, GENREPT (contains required data from SCRCST), and MODLOUT files. The

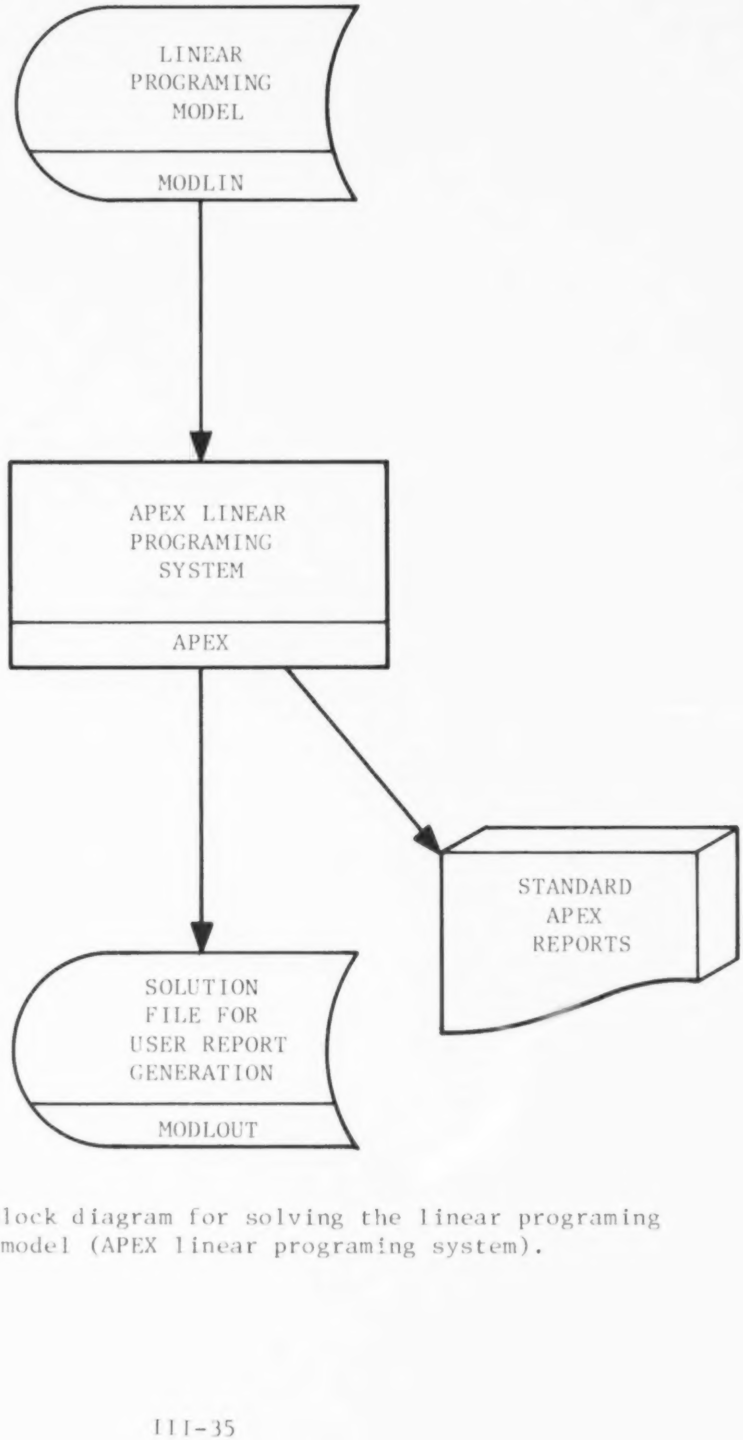

LINEAR
PROGRAMING
MODEL
MODLIN
APEX LINEAR
PROGRAMING
SYSTEM
APEX
STANDARD
APEX
REPORTS
SOLUTION
FILE FOR
USER REPORT
GENERATION
MODLOUT

Figure III-11. Block diagram for solving the linear programing marketing model (APEX linear programing system).

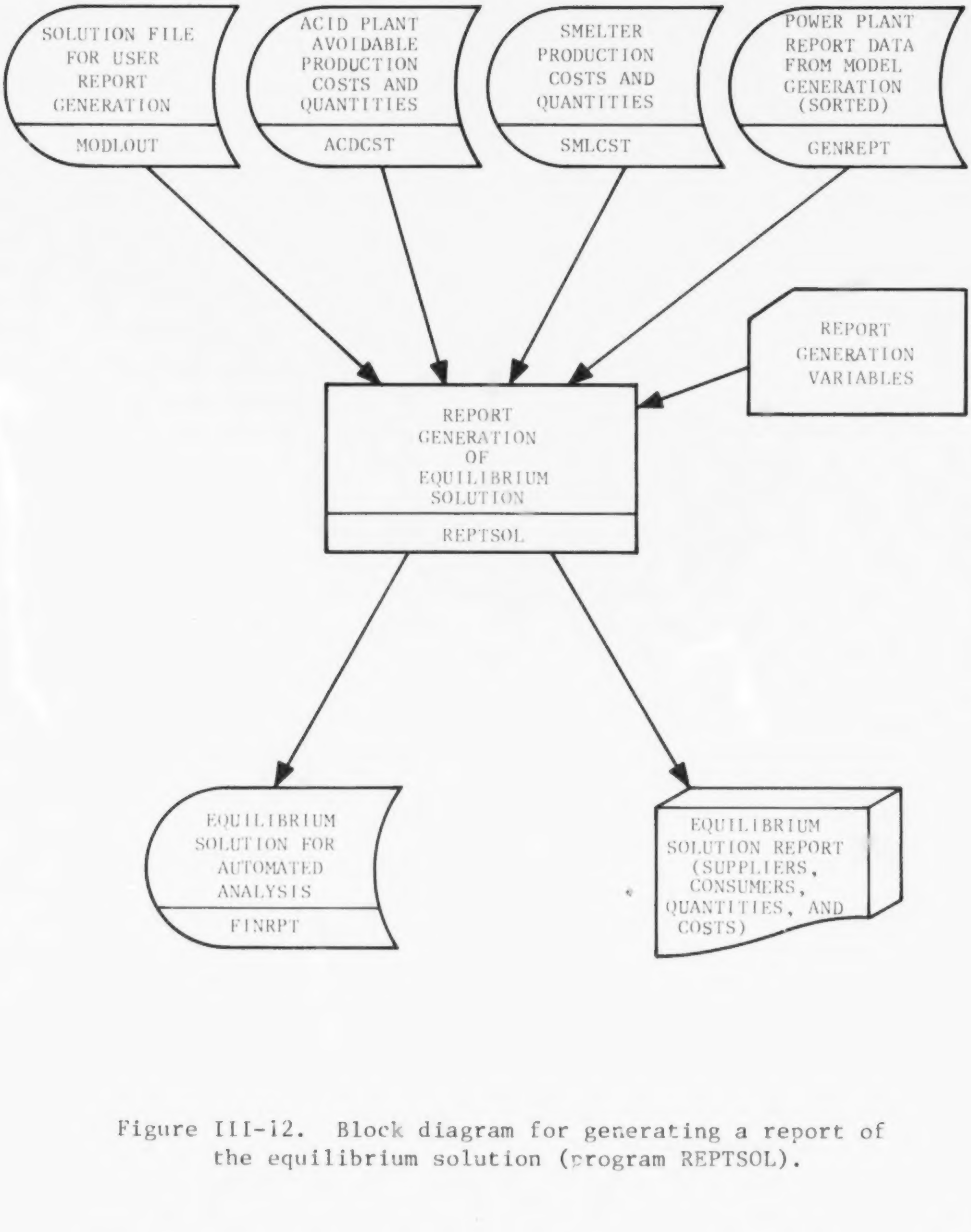

SOLUTION FILE FOR USER REPORT GENERATION
MODLOUT
ACID PLANT AVOIDABLE PRODUCTION COSTS AND QUANTITIES
ACDCST
SMELTER PRODUCTION COSTS AND QUANTITIES
SMLCST
POWER PLANT REPORT DATA FROM MODEL GENERATION (SORTED)
GENREPT
REPORT GENERATION VARIABLES
REPORT GENERATION OF EQUILIBRIUM SOLUTION
REPTSOL
EQUILIBRIUM SOLUTION FOR AUTOMATED ANALYSIS
FINRPT
EQUILIBRIUM SOLUTION REPORT (SUPPLIERS, CONSUMERS, QUANTITIES, AND COSTS)

Figure III-12. Block diagram for generating a report of the equilibrium solution (program REPTSOL).

GENREPT file contains power plant data required in the report that could not be included in the model itself and the MODLOUT file contains the solution of the model from APEX. The title that will be used to identify the overall report is provided by the user. The report is currently divided into six sections as follows:

1. Cost and sales summary
2. Projected acid plant purchases
3. Projected sales by eastern smelters
4. Projected sales from the West (via transshipment terminals)
5. Projected sales from Canada (via transshipment terminals)
6. Projected power plant sales

FINAL STRATEGY SELECTION PROCEDURE

Even after the final report is produced the implications of the model solution must be analyzed before the strategy selection process is complete. If the model solution indicates a potential market for the total projected production considered in the model from a given power plant, a marketable byproduct strategy is selected. If the model solution indicates no potential market for any part of the projected production considered in the model from a given power plant, a marketable byproduct strategy is not indicated and the otherwise-best strategy must be selected.

The otherwise-best strategy depends on the option that was specified in the GENPGM program to control how the ACFL value was to be used. If the option was specified to allow the system to choose the best alternative, the costs of a disposable byproduct scrubbing strategy are compared to the costs of a clean fuel strategy (based upon the ACFL value used) and the least-cost strategy of the two is selected. If the option specified in the GENPGM program was that a clean fuel preference was to be used, the otherwise-best strategy compared to a byproduct marketing strategy will be a disposable byproduct strategy because a clean fuel strategy would have been selected in the first place if it was less costly at the ACFL value used.

Strategy selection is not as obvious when the model solution indicates a potential market for only a part of the projected production considered in the model from a given power plant. The plants where this occurs must be analyzed on a case-by-case basis. The problem is further compounded if the plant was divided by the GENPGM program into a partial clean fuel - partial scrubbing strategy, with the model solution used to select the final strategy. The ACFL value, the SCRCST data for the plant, the GENPGM preselection results (GENREPT), and the model solution must all be analyzed to determine what part of the total quantity considered for marketing was produced from each boiler. These quantities must be manually compared to the potential market quantity indicated in the model solution. Even though the GENPGM program did not allow a boiler to be divided or split between strategies, the quantities considered for marketing in the model are not on a boiler basis and a market potential may be indicated for only a fraction of the marketable byproduct production from a given boiler. As previously discussed a combination of two different scrubbing strategies at a single plant is improbable so the production from each boiler (and the associated costs) must be compared to the potential market quantity and grouped into either a mixed clean fuel - marketable byproduct strategy, a mixed clean fuel - disposable byproduct strategy, or a total clean fuel strategy. Based on the results of previous models, even when the market potential is very close to projected production quantities a split strategy probably cannot be avoided. Final strategy selection for plants with a market potential for only part of the projected production can be difficult. When this occurs, in order to avoid a very arbitrary and subjective strategy selection, further analysis including additional model runs may be required.

If the results of a single model based on only one ACFL value are inconclusive, or if more information is required for other reasons, additional models can be built using different ACFL values so that strategy selection is based on trends rather than a single set of conditions. Using different ACFL values serves two purposes. In addition to allowing an evaluation of the effects on strategy selection as clean fuel strategy costs vary, the ACFL value used directly affects the total potential supply quantities that are considered in the model and therefore the amount of competition present for the available market. As the ACFL increases, a marketable byproduct strategy becomes an option for more and more power plants. At higher ACFL values, power plants that continue to have a market potential in the presence of greater competition resulting from the additional supply considered are those plants with relatively low incremental costs, geographic advantages for the available market, or both.

Another factor that can significantly affect strategy selection, in addition to the changes in supply that were just discussed, is changes in demand. The avoidable production costs used to determine potential demand are very dependent on sulfur costs (sulfur-related costs are typically the most significant portion of avoidable production costs). In order to model the results of potential reductions in sulfur costs (which would reduce avoidable production costs and in turn reduce the potential demand for power plant byproduct acid), the sulfur cost in the ACDPAR file can be modified and new avoidable production costs generated by executing the GENACD program. Additional models can then be built to determine effects on strategy selection as a result of changes in demand.

Typically, several models are developed by varying both the potential supply (by using different ACFL values) and the potential demand (by using different sulfur cost values). Based on the results from all of the models, the power plants selected for marketable byproduct strategies are those where the model solutions indicate a continuing market potential over a range of increasing levels of supply and decreasing levels of demand.

IV. FILE AND RECORD DESCRIPTIONS

This section contains the file and record descriptions and output report formats for the byproduct marketing system. For the binary files a general narrative is provided because a listing of the actual data must be decoded and is not directly useful.

SUPPLY SUBSYSTEM

Data files used in the supply subsystem are listed in Table IV-1.

Power Plant Data Base

A graphic representation of the power plant data base is shown in Figure IV-1. A System 2000 data base description of the power plant data used in the byproduct marketing systen is shown in Tables IV-2 through IV-5.

The graphic representation shows three levels in the data base. The highest level contains general power plant data such as location, name, and FPC number. The second level contains three different categories of data, referred to as "repeating groups" in the terminology of System 2000. These repeating groups contain plant data by year, emission regulations, and general boiler data. As shown in the graphic representation they are subsets of the general plant level and are relatively independent of each other. The third level repeating groups contain regulations by pollutant, fuel type, and equipment identification; boiler and stack configurations; and boiler data by year. The regulations by type are a subset of the regulations repeating group; the remaining groups at the third level are subsets of the general boiler data repeating group.

The initial data base was created from the FPC Form 67 data for the years 1969-1973 including projected data for 1978 and 1983. Additional data are included from the EDS data base, the CDS data base, and PEDCo reports; from various other sources to allow the addition of SPLC and FIPS state and county codes; and from sources containing projections of boilers scheduled to come on-line that were not included in the Form 67 data. The Form 67 data are primarily from pages 2, 5, 9, and 14; a pseudo page of 00 is used by FPC to include data items not actually filed by the utilities on Form 67. The units of measure are the same as reported on Form 67, used in the EDS and CDS systems, or reported by PEDCo.

TABLE IV-1. FILES USED IN THE SUPPLY SUBSYSTEM

File name	Description
PLANTS	Data base for power plants, System 2000 format (input to PROJECT)
SASDAT6	Investments and operating factors for the various scrubbing processes (input to STMCAP)
SCRPRC	Cost data that correspond to the investment and operating factors by year (input to STMCAP)
LIMEEST	Estimated delivered cost of limestone to each power plant (input to ADDLIME)
SCRSIT	Site-factor adjustments for specific plants (input to STMCAP)
PLAS	Projected plant-level data (output from PROJECT, input to ADDLIME and optionally to STMCAP)
BLAS	Projected boiler-level data (output from PROJECT, input to STMCAP)
UPLIME	PLAS file merged with LIMEEST (output from ADDLIME, input to STMCAP)
SCRCST	Power plant scrubbing costs and related quantities (output from STMCAP, input to manual procedure in transportation subsystem, input to GENPGM in linear programing subsystem)

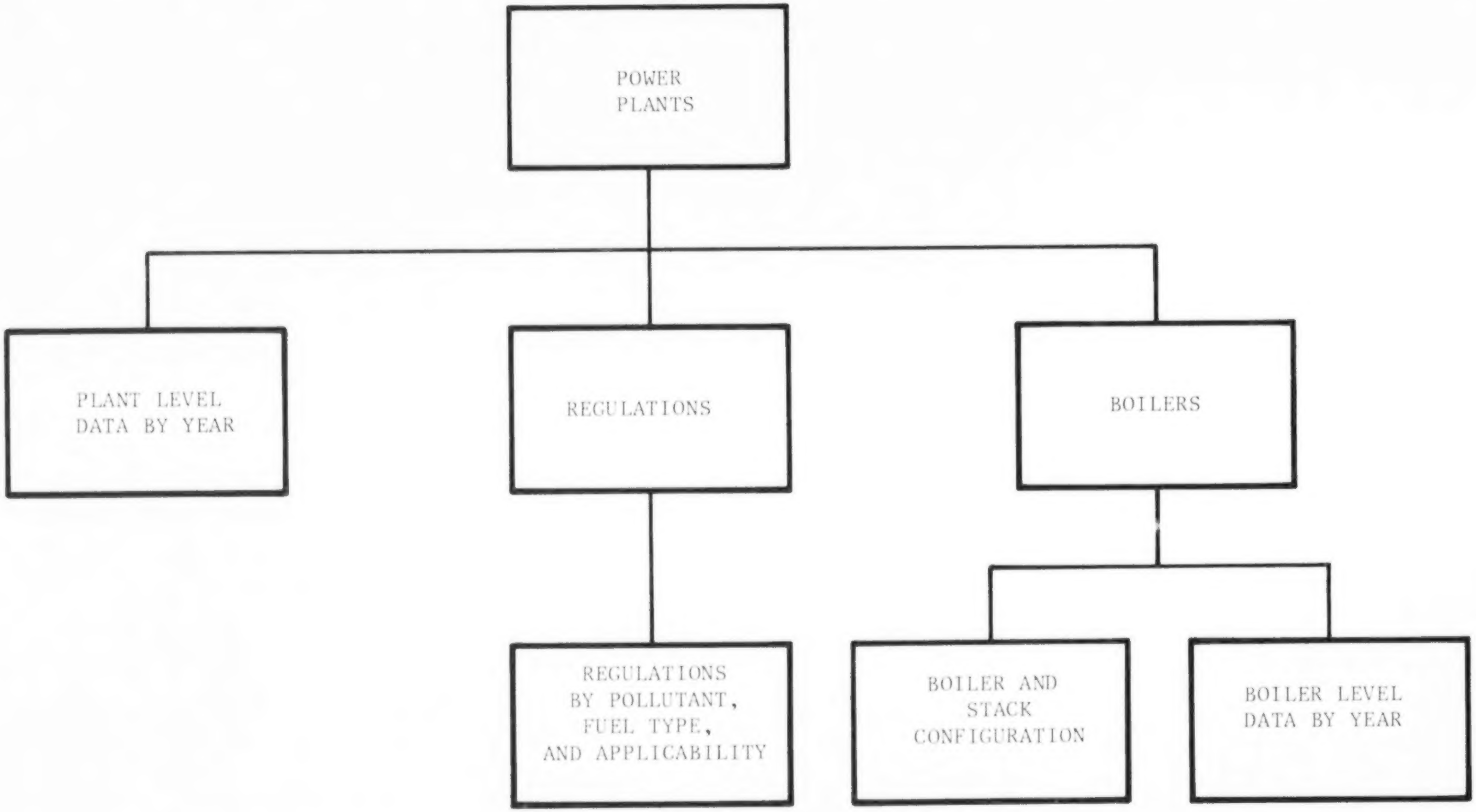

POWER PLANTS
PLANT LEVEL DATA BY YEAR
REGULATIONS
BOILERS
REGULATIONS BY POLLUTANT, FUEL TYPE, AND APPLICABILITY
BOILER AND STACK CONFIGURATION
BOILER LEVEL DATA BY YEAR

Figure IV-1. Power plant data base structure.

TABLE IV-2. POWER PLANT DATA BASE PLANT DATA

```
DATA BASE NAME IS PWRPLTS

 100*  PLANT-NMBR (NAME X(10))
 110*  PLANT-NAME (NON-KEY NAME X(30))
 120*  UTILITY-NMBR (NAME X(6))
 130*  UTILITY-NAME (NON-KEY NAME X(30))
 140*  FIPS-REGION (NON-KEY INTEGER NUMBER 99)
 150*  FIPS-STATE (INTEGER NUMBER 99)
 160*  FIPS-COUNTY (NON-KEY INTEGER NUMBER 999)
 170*  AQCR (NON-KEY INTEGER NUMBER 999)
 180*  NEDS-STATE (NAME XX)
 190*  NEDS-COUNTY (NAME XXXX)
 200*  NEDS-PLANT (NAME XXXX)
 210*  SPLC (INTEGER NUMBER 9(6))
 220*  PEDCO-MILES-TO-POND (DECIMAL NUMBER 9999.9)
 340*  CDS-COMPLIANCE-CODE (INTEGER NUMBER 9 WITH MANY FUTURE ADDITIONS)
 500*  PLANT-DATA-BY-YEAR (RG)
   510*  PLANT-COAL-CONSUMP (DECIMAL NUMBER 9(9).99 IN 500)
   520*  PLANT-COAL-BTU (DECIMAL NUMBER 9(9).99 IN 500)
   530*  PLANT-COAL-SULFUR (NON-KEY DECIMAL NUMBER 9.9999 IN 500)
   540*  PLANT-COAL-ASH (NON-KEY DECIMAL NUMBER 9.9999 IN 500)
   550*  PLANT-COAL-H2O (NON-KEY DECIMAL NUMBER 9.9999 IN 500)
   560*  PLANT-OIL-CONSUMP (DECIMAL NUMBER 9(9).99 IN 500)
   570*  PLANT-OIL-BTU (DECIMAL NUMBER 9(9).99 IN 500)
   580*  PLANT-OIL-SULFUR (NON-KEY DECIMAL NUMBER 9.9999 IN 500)
   590*  PLANT-GAS-CONSUMP (DECIMAL NUMBER 9(9).99 IN 500)
   600*  PLANT-GAS-BTU (DECIMAL NUMBER 9(9).99 IN 500)
   610*  PLANT-FUEL-BASIS (NON-KEY NAME X IN 500)
   620*  PLANT-NET-MW-GEN (DECIMAL NUMBER 9(9).99 IN 500)
   630*  PLANT-HEAT-RATE (DECIMAL NUMBER 9(9).99 IN 500)
   640*  PLANT-CAPACITY (DECIMAL NUMBER 9(9).99 IN 500)
   650*  PLANT-DATA-YEAR (INTEGER NUMBER 9999 IN 500 WITH MANY FUTURE
         ADDITIONS)
```

TABLE IV-3. POWER PLANT DATA BASE REGULATION DATA

```
1000*  REGULATIONS (RG)
  1010*  REG-POLLUTANT-NAME (NAME XXX IN 1000 WITH MANY FUTURE ADDITIONS)
  1020*  REG-FUEL-TYPE (NAME X IN 1000 WITH MANY FUTURE ADDITIONS)
  1030*  REG-SOURCE (NAME X(6) IN 1000)
  1040*  REG-TYPE-CODE (NAME XXXX IN 1000 WITH MANY FUTURE ADDITIONS)
  1500*  REGS-BY-POLL-FUEL-EQUIP-ID (RG IN 1000)
    1510*  REG-EQUIP-ID (NAME X(10) IN 1500)
    1520*  REG-VALUE (DECIMAL NUMBER 9(5).99 IN 1500)
    1530*  REG-UNITS-CODE (NAME XX IN 1500)
    1540*  REG-UNITS-TEXT (NON-KEY NAME X(20) IN 1500)
    1550*  REG-NEW-SOURCE-CODE (NAME X(5) IN 1500 WITH MANY FUTURE ADD
           ITIONS)
    1560*  REGAPPLICABILITY-CODE (NAME X IN 1500 WITH MANY FUTURE ADDI
           TIONS)
    1570*  REG-HEAT-INPUT-BASIS-CODE (NAME X IN 1500)
    1580*  REG-CONV-TO-PCT-S (DECIMAL NUMBER 99.99 IN 1500)
    1590*  REG-CONV-TO-LB-SO2-MMBTU (DECIMAL NUMBER 99.99 IN 1500)
    1600*  REG-CONV-TO-LB-TSP-MMBTU (DECIMAL NUMBER 99.99 IN 1500)
    1610*  REG-CONV-TO-LB-NOX-MMBTU (DECIMAL NUMBER 99.99 IN 1500)
    1620*  REG-EXCESS-AIR (INTEGER NUMBER 99 IN 1500 WITH MANY FUTURE
           ADDITIONS)
    1630*  REG-DATE-APPROVED (DATE IN 1500)
    1640*  REG-AVG-TIME-CODE (NAME XXX IN 1500)
    1650*  REG-COMPLIANCE-DATE (DATE IN 1500)
    1660*  REG-VALUE-STATUS (NAME X(7) IN 1500)
    1670*  REG-VALUE-MAX-OF (DECIMAL NUMBER 9(5).99 IN 1500 WITH MANY
           FUTURE ADDITIONS)
    1680*  REG-COMPUTED-FIELD (DECIMAL NUMBER 9(5).99 IN 1500)
    1690*  REG-HEAT (NAME X IN 1500 WITH MANY FUTURE ADDITIONS)
```

TABLE IV-4. POWER PLANT DATA BASE BOILER DATA (GENERAL)

```
2000*  BOILERS (RG)
  2010*  BOILER-ID (NAME XXX IN 2000 WITH MANY FUTURE ADDITIONS)
  2020*  NEDS-POINT-ID (NON-KEY NAME XX IN 2000)
  2030*  TOTAL-STACKS-SERVED (NON-KEY INTEGER NUMBER 9(7) IN 2000)
  2040*  TOTAL-GENERATORS-SERVED (NON-KEY INTEGER NUMBER 9(7) IN 2000)
  2050*  BOILER-MANUFACTURER (NON-KEY NAME XXXX IN 2000)
  2060*  BOILER-YEAR-MADE (NAME XXXX IN 2000 WITH MANY FUTURE ADDITIONS)
  2070*  ASSOC-GEN-CAPACITY (DECIMAL NUMBER 9(9).99 IN 2000)
  2080*  MAX-STEAM-CAPACITY (NON-KEY DECIMAL NUMBER 9(9).99 IN 2000)
  2090*  COAL-FEED-RATE (NON-KEY DECIMAL NUMBER 9(9).99 IN 2000)
  2100*  OIL-FEED-RATE (NON-KEY DECIMAL NUMBER 9(9).99 IN 2000)
  2110*  GAS-FEED-RATE (NON-KEY DECIMAL NUMBER 9(9).99 IN 2000)
  2120*  BOILER-EFF-100-PCT (NON-KEY DECIMAL NUMBER 9.9999 IN 2000)
  2130*  BOILER-EFF-75-PCT (NON-KEY DECIMAL NUMBER 9.9999 IN 2000)
  2140*  BOILER-EFF-50-PCT (NON-KEY DECIMAL NUMBER 9.9999 IN 2000)
  2150*  TOTAL-AIR (NON-KEY DECIMAL NUMBER 9(9).99 IN 2000)
  2160*  EXCESS-AIR (NON-KEY DECIMAL NUMBER 9.9999 IN 2000)
  2170*  WET-DRY-BOTTOM (NON-KEY NAME X IN 2000)
  2180*  FLY-ASH (NON-KEY NAME X IN 2000)
  2190*  FIRE-TYPE-1 (NON-KEY NAME XXXX IN 2000)
  2200*  FIRE-TYPE-2 (NON-KEY NAME XXXX IN 2000)
  2210*  FIRE-TYPE-3 (NON-KEY NAME XXXX IN 2000)
  2220*  FIRE-TYPE-4 (NON-KEY NAME XXXX IN 2000)
  2230*  PEDCO-RETROFIT-DFFCLTY-FCTR (DECIMAL NUMBER 9.999 IN 2000)
  2240*  PEDCO-START-UP-DATE (NAME X(7) IN 2000)
  2250*  PEDCO-REG-STATUS (NAME X IN 2000 WITH MANY FUTURE ADDITIONS)
  2260*  PEDCO-NEW-RETROFIT (NAME X IN 2000)
  2270*  PEDCO-SIZE-FLU-GAS-DESULFURING (INTEGER NUMBER 9999 IN 2000)
  2280*  PEDCO-PROCESS (NAME X(15) IN 2000)
  2290*  PEDCO-VENDOR (NAME X(15) IN 2000)
  2600*  STACKS-SERVED (RG IN 2000)
    2610*  STACK-ID (NAME XXX IN 2600)
```

TABLE IV-5. POWER PLANT DATA BASE BOILER DATA (BY YEAR)

```
3000*  BOILER-DATA-BY-YEAR (RG IN 2000)
  3010*  BOILER-COAL-CONSUMP (NON-KEY DECIMAL NUMBER 9(9).99 IN 3000)
  3020*  BOILER-OIL-CONSUMP (NON-KEY DECIMAL NUMBER 9(9).99 IN 3000)
  3030*  BOILER-GAS-CONSUMP (NON-KEY DECIMAL NUMBER 9(9).99 IN 3000)
  3040*  WINTER-WKDAY-HIGH (NON-KEY NAME X IN 3000)
  3050*  WINTER-WKDAY-LOW (NON-KEY NAME X IN 3000)
  3060*  WINTER-WKEND-HIGH (NON-KEY NAME X IN 3000)
  3070*  WINTER-WKEND-LOW (NON-KEY NAME X IN 3000)
  3080*  SUMMER-WKDAY-HIGH (NON-KEY NAME X IN 3000)
  3090*  SUMMER-WKDAY-LOW (NON-KEY NAME X IN 3000)
  3100*  SUMMER-WKEND-HIGH (NON-KEY NAME X IN 3000)
  3110*  SUMMER-WKEND-LOW (NON-KEY NAME X IN 3000)
  3120*  LOW-PERIOD-WKDAY-HIGH (NON-KEY NAME X IN 3000)
  3130*  LOW-PERIOD-WKDAY-LOW (NON-KEY NAME X IN 3000)
  3140*  LOW-PERIOD-WKEND-HIGH (NON-KEY NAME X IN 3000)
  3150*  LOW-PERIOD-WKEND-LOW (NON-KEY NAME X IN 3000)
  3160*  BOILER-HOURS-OPERATED (INTEGER NUMBER 9999 IN 3000)
  3170*  BOILER-CAPACITY-FACTOR (DECIMAL NUMBER 9.9999 IN 3000 WITH
         MANY FUTURE ADDITIONS)
  3180*  BOILER-COAL-PARTICULATE (NON-KEY DECIMAL NUMBER 9(9).99 IN
         3000)
  3190*  BOILER-OIL-PARTICULATE (NON-KEY DECIMAL NUMBER 9(9).99 IN
         3000)
  3200*  BOILER-COAL-SOX (NON-KEY DECIMAL NUMBER 9(9).99 IN 3000)
  3210*  BOILER-OIL-SOX (NON-KEY DECIMAL NUMBER 9(9).99 IN 3000)
  3220*  BOILER-COAL-NOX (NON-KEY DECIMAL NUMBER 9(9).99 IN 3000)
  3230*  BOILER-OIL-NOX (NON-KEY DECIMAL NUMBER 9(9).99 IN 3000)
  3240*  BOILER-GAS-NOX (NON-KEY DECIMAL NUMBER 9(9).99 IN 3000)
  3250*  SPLIT-FUEL-CONSUMP-INDEX (INTEGER NUMBER 9 IN 3000 WITH MAN
         Y FUTURE ADDITIONS)
  3260*  SPLIT-FUEL-CONSUMP-CNTR (INTEGER NUMBER 99 IN 3000 WITH MAN
         Y FUTURE ADDITIONS)
  3270*  BOILER-DATA-YEAR (NAME XXXX IN 3000 WITH MANY FUTURE ADDITI
         ONS)
```

The repeating groups developed from the FPC Form 67 data utilize the plant-level and boiler-level data for the years that actual data were reported plus the 5- and 10-year plant-level data projections.

The plant-level repeating group occurs one time for each power plant. It is based on either Form 67 data for the latest year reported or new plants that are scheduled in the future.

The plant-data-by-year repeating group occurs one time for each year that plant-level data were either reported or projected on Form 67. A plant with complete data for all years plus 5- and 10-year projections has seven occurrences at this level in the current data base, 1969-1973, 1978, and 1983. As the data base is updated three additional occurrences can be added for each year. For example, if the data reported for 1974 are added, the 1974 actual plant-level data as well as the 5- and 10-year plant-level projections for 1979 and 1984 can be added (assuming the data are reported as in previous years).

The regulation repeating group is built based on data extracted from the EDS data base. As the data base is updated these values are modified, added, or deleted as required.

The boiler-level repeating group corresponds to the plant-level repeating group. Because boiler data are not provided on Form 67 beyond the year that actual consumption information is reported, other sources are used to identify boilers projected to come on-line between the last year reported and the year necessary for projections. This allows boiler-level fuel allocation estimates to be calculated for projected years. The repeating group occurs one time for each boiler, either reported on Form 67 or added based on other sources.

The stack repeating group is based on Form 67 data. There is one occurrence per boiler for each stack serving the boiler.

The boiler-data-by-year repeating group corresponds to the plant-data-by-year repeating group except that occurrences are based on actual consumption data only, not projected data. A boiler with complete data for all years will have five occurrences at this level in the current data base, one for each of the years 1969-1973. As the data base is updated, one occurrence can be added for each year.

Neither detailed knowledge of the data base nor direct access into it is required to use the system. The extract-projection program is the procedural language interface (PLI) between the data base and the remainder of the system. Output from the program consists of standard sequential data files which are much simpler and less costly to access. Any user modifications required should typically be made to the sequential files, not directly to the data base. If the data base must be directly accessed the appropriate System 2000 manual must be used (see Appendix B).

Because the power plant data base was designed to satisfy several requirements rather than being limited to a single system, the repeating groups contain components that are not used in the current byproduct marketing system. Many or all of these components or repeating groups may be deleted and other components or repeating groups may be added as continuing requirements dictate. No assumptions should be made as to the continuing availability or validity of any component or repeating group not used directly in the byproduct marketing system. The PLI projection program (PROJECT) source listing must be examined to determine the components and repeating groups being used at any given time. As modifications are made that affect the components and repeating groups used (other than merely adding or updating data values), new data base descriptions can be made available. However, because direct data base access is unnecessary to use the system, if a modified PLI projection program is provided that corresponds to the modified data base, system usage as described will be unaffected.

The current data base contains about 6 million characters of data so careless or unnecessary use should be avoided. As an example, depending on the particular System 2000 command, costs can vary from a few dollars to hundreds of dollars for a single command. This precaution applies particularly to commands in update mode.

Other Supply Subsystem File and Record Descriptions

Examples of the remaining files and applicable printed reports are shown in Tables IV-6 through IV-23. (Details and examples of NAMELIST usage as shown in several of the tables can be found in the FORTRAN manual listed in Appendix B.)

TABLE IV-6. FILE FORMAT FOR DELIVERED COSTS

OF LIMESTONE TO POWER PLANTS (LIMEEST)

Field number	Description	Format
1	FPC number	I10
2	Delivered cost of limestone	F6.2

TABLE IV-7. FILE FORMAT FOR SCRUBBER INVESTMENT AND OPERATING FACTORS

(SASDAT6)

Field number	Description	Format	SASIN NAMELIST variable names for user override
1	Process index (1-6)	I1	IU
2	Boiler status (1 - new, 2 - old)	I1	JU
3	Sequence code	I3	ISEQU
4	Not used	1X	-
5	Area index (1-13)	I2	KU
6	Not used	1X	-
7	Price index (1-24)	I2	LU
8	Not used	1X	-
9	Base scale or quantity	F9.0	AU
10	Not used	1X	-
11	Sulfur coefficient	F5.3	A1U
12	Not used	1X	-
13	Air coefficient	F5.3	A2U

TABLE IV-8. FILE FORMAT FOR SCRUBBER INVESTMENT AND OPERATING COSTS (SCRPRC)

Field number	Description	Unit	Format
1	Capital	0	NAMELIST
2	Labor	$/hr	NAMELIST
3	No. 2 fuel oil	$/gal	NAMELIST
4	No. 6 fuel oil	$/gal	NAMELIST
5	Natural gas	$\$/\mathrm{kft}^3$	NAMELIST
6	Steam (500 psi)	$/klb	NAMELIST
7	Process water	$/kgal	NAMELIST
8	Electricity	$/kWh	NAMELIST
9	Heat credit	$/MBtu	NAMELIST
10	Limestone	$/ton	NAMELIST
11	Lime (limestone)	$/ton	NAMELIST
12	Lime (magnesium oxide)	$/ton	NAMELIST
13	Lime (sodium)	$/ton	NAMELIST
14	Magnesium oxide	$/ton	NAMELIST
15	Coke	$/ton	NAMELIST
16	Vanadium catalyst	$/liter	NAMELIST
17	Vanadium catalyst	$/liter	NAMELIST
18	Sodium carbonate	$/ton	NAMELIST
19	Antioxidant	$/lb	NAMELIST
20	Catalyst	$/lb	NAMELIST
21	Analyses	$/hr	NAMELIST
22	Sulfuric acid	$/ton	NAMELIST
23	Water treatment cost	$/kgal	NAMELIST
24	Offsite disposal transport rate	$/ton	NAMELIST
25	Applicable year		NAMELIST

Note: The PRICIN NAMELIST has a variable name of PRICE that must be used as well as the appropriate subscript (field number above) when user overrides are used.

TABLE IV-9. FILE FORMAT FOR POWER PLANT

SITE-SPECIFIC ADJUSTMENTS (SCRSIT)

Field number	Description	Format
1	FPC number	NAMELIST
2	Site factor for process No. 1 (currently limestone)	NAMELIST
3	Site factor for process No. 2 (designed for lime, not used currently)	NAMELIST
4	Site factor for process No. 3 (currently magnesia)	NAMELIST
5	Site factor for process No. 4 (currently sodium solution)	NAMELIST
6	Site factor for process No. 5 (designed for catalytic oxidation, not used currently)	NAMELIST
7	Site factor for process No. 6 (currently gypsum)	NAMELIST

TABLE IV-10. FILE FORMAT FOR PROJECTED PLANT-LEVEL DATA (PLAS)

Field number	Description	Format	PLANTIN NAMELIST variable names for user data
Record 1			
1	FPC number	I10	IFPC
2	Not used	1X	-
3	SPLC	I6	ISPLC
4	Coal heat content	F9.1	BTUCOL
5	Coal sulfur content	F5.3	SULCOL
6	Oil heat content	F10.1	BTUOIL
7	Oil sulfur content	F5.3	SULOIL
8	Gas heat content	F10.1	BTUGAS
9	Plant heat rate	F10.1	HTRATE
10	Test field 1	F7.0	-
11	Test field 2	F7.0	-
12	Test field 3	F7.0	-
13	Test field 4	F7.0	-
14	Test field 5	F6.0	-
15	Test field 6	F4.2	-
16	Plant capacity	F6.0	-
17	Not used	3X	-
18	Data case identifier	1X	-
Record 2			
1	Plant name	3A10	-[a]
2	Distance to pond	F10.2	PEDCO
3	Not used	3X	-
4	Not used	6X	-
Record 3			
1	SIP type (P or B)	A1	ISIP1[b]
2	Not used	3X	-
3	Coal SIP code	I2	ISIP2
4	Not used	3X	-
5	Coal regulation value	F10.2	REGC
6	Test field 1	F10.2	-
7	Not used	3X	-
8	Oil SIP code (if different from coal)	I2	ISIPO
9	Oil regulation value	F10.2	REGO
10	Test field 2	F10.2	-

a. Plant name is not included in the NAMELIST data; it must be provided as a separate record following all PLANTIN NAMELIST data; FORMAT is still 3A10.

b. Neither a 'B' for a boiler-level regulation nor a 'P' for a plant-level regulation is an allowable NAMELIST value. A coded equivalent must be used to overcome the limitation.

For a boiler regulation - ..., ISIP1 = 2, ...
For a plant regulation - ..., ISIP1 = 16, ...

TABLE IV-11. FILE FORMAT FOR PROJECTGED BOILER-LEVEL DATA (BLAS)

Field number	Description	Format	BLRIN NAMELIST variable names for user data
Record 1			
1	Boiler identification	A3	IB
2	Not used	3X	-
3	Boiler capacity	F11.2	GENCAP
4	Boiler air rate	F11.2	AIRI
5	Coal consumption, ktons	F11.2	TOTCOLI
6	Oil consumption, kbbl	F11.2	TOTOILI
7	Gas consumption, kft^3	F11.2	TOTGASI
8	Boiler capacity factor	F9.4	CAPFPC
9	Not used	3X	-
10	Boiler startup year	F4.0	STRTYRI
11	Not used	2X	-
12	Number of stacks served	I7	-
13	Stack identification	5A3	-
14	FPC number	I10	IFPCB
15	PEDCo scrubber status	I1	-
16	Retrofit difficulty factor	F5.3	RETRO
Record 2			
1	Boiler identification	A3	-
2	Not used	3X	-
3	Coal SIP code	I2	ISIP2
4	Not used	3X	-
5	Coal regulation value	F10.2	REGC
6	Test field 1	F10.2	-
7	Not used	3X	-
8	Oil SIP code (if different from coal)	I2	ISIPO
9	Oil regulation value	F10.2	REGO
10	Test field 2	F10.2	-

Note: The following variable names may also be specified on a boiler basis for user-provided BLRIN NAMELIST data:

Coal heat content - HRCOAL, coal sulfur content - SULCOL, oil heat content - BTUOIL, oil sulfur content - SULOIL, gas heat content - BTUGAS, and process code for detailed analysis of costs - IPROC (1 - limestone, 2 - not used, 3 - magnesia, 4 - sodium, 5 - not used, 6 - gypsum).

TABLE IV-12. FILE FORMAT FOR PROJECTED PLANT-LEVEL DATA WITH DELIVERED LIMESTONE COSTS INCLUDED (UPLIME)

Field number	Description	Format	PLANTIN NAMELIST variable names for user data
Record 1			
1	FPC number	I10	IFPC
2	Not used	1X	-
3	SPLC	I6	ISPLC
4	Coal heat content	F9.1	BTUCOL
5	Coal sulfur content	F5.3	SULCOL
6	Oil heat content	F10.1	BTUOIL
7	Oil sulfur content	F5.3	SULOIL
8	Gas heat content	F10.1	BTUGAS
9	Plant heat rate	F10.1	HTRATE
10	Test field 1	F7.0	-
11	Test field 2	F7.0	-
12	Test field 3	F7.0	-
13	Test field 4	F7.0	-
14	Test field 5	F6.0	-
15	Test field 6	F4.2	-
16	Plant capacity	F6.0	-
17	Not used	3X	-
18	Data case identifier	1X	-
Record 2			
1	Plant name	3A10	-[a]
2	Distance to pond (miles)	F10.2	PEDCO
3	Not used	3X	-
4	Limestone cost (delivered, cents/ton)	F6.2	VLIME
Record 3			
1	SIP type (P or B)	A1	ISIP1[b]
2	Not used	3X	-
3	Coal SIP code	I2	ISIP2
4	Not used	3X	-
5	Coal regulation value	F10.2	REGC
6	Test field 1	F10.2	-
7	Not used	3X	-
8	Oil SIP code (if different from coal)	I2	ISIPO
9	Oil regulation value	F10.2	REGO
10	Test field 2	F10.2	-

a. Plant name is not included in the NAMELIST data; it must be provided as a separate record following all PLANTIN NAMELIST data; FORMAT is still 3A10.

b. Neither a 'B' for a boiler-level regulation nor a 'P' for a plant-level regulation is an allowable NAMELIST value. A coded equivalent must be used to overcome the limitation.

For a boiler regulation - ..., ISIP1 = 2, ...
For a plant regulation - ..., ISIP1 = 16, ...

TABLE IV-13. FILE FORMAT FOR CALCULATED POWER PLANT SCRUBBING COSTS AND RELATED QUANTITIES (SCRCST)

Field number	Description	Format
1	FPC number of power plant	I10
2	Power plant SPLC	I6
3	SIP indicator (1 for plant, 2 for boiler)	I1
4	Number of boilers (total)	I2
5	Number of boilers with adequate information for calculations	I2
6	Number of boilers that must be scrubbed to meet compliance	I2
7	Boiler identification	A3
8	Test field	F10.0
9	Heat input, MBtu (cumulative)	F10.0
10	Emissions removed by scrubbing (cumulative total including this boiler, tons sulfur)	F10.0
11	Total dollar cost, limestone scrubbing (cumulative)	F10.0
12	Cents/MBtu cost of limestone scrubbing (cumulative)	F10.4
13	Total dollar cost, magnesium oxide scrubbing (cumulative)	F10.0
14	Total dollar cost, gypsum scrubbing (cumulative)	F10.0
15	Total dollar cost, sodium scrubbing (cumulative)	F10.0
16	Emissions removed by scrubbing, cumulative total including this boiler, but limited to the point that compliance is reached, tons sulfur (compare to field 10 above)	F10.0
17	Plant name	3A10

TABLE IV-14. REPORT FORMAT FOR OPTIONS AND OVERRIDES

```
   AVAILABLE OPTIONS AND DEFAULTS

 IN= 5  INPUT FILE FOR OVERIDE AND SIMULATED DATA
 IO= 6  OUTPUT FILE FOR LISTING---SWITCHABLE 6/20/30/40/
 KSIM= 0  READ NAMELIST PLANT/BOILER RECORDS FROM IN
 KCHECK= 0  DETAIL OUTPUT FROM COSTNEW ON FILE IO
 KOFF= 0  FORCES OFF-SITE POND CALCULATIONS CHECKOUT
 KSCAN= 0  WRITE  A 1-LINE RECORD FOR EACH PLANT ON IO=KSCAN
 KEMISS= 0  PLANT'BOILER EMISSION DATA ON IO=KEMISS
 KCOSTLP= 0  WRITES LP TAPE10, REPORT ON KCOSTLP
 KCOSTP= 0  PLANT SUMMARY ON KCOSTP (KCOSTLP ALSO ACTIVE
 KPRICE= 0  NON-ZERO CHANGES TO PRICES FOLLOW OVERIDE DATA
 KSAS= 0  NON-ZERO CHANGES TO SASDATA FOLLOW OVERIDE
 LSAS= 0  NON-ZERO  LISTS CURRENT SASDATA ' PRICES ON IO
 KEDIT= 0  NONZERO STOP AFTER LISTING SASDATA
 LCP= 0  ALLOWS DETAIL PRINT FROM COSTNEW (CHECKOUT)
 KSTART          0 STARTING FPC NUMBER FOR SELECTED PLANTS
 KSTOP=9999999999  ENDING FPC NUMBER SELECTED
 NAMELIST OPTIONS SELECTED FOR THIS RUN APPEAR ON IO


$OPTIONS
KSAS     = 0,
LSAS     = 0,
LCP      = 0,
KPRICE   = 0,
KEDIT    = 0,
KOFF     = 0,
KSIM     = 0,
IN       = 5,
IO       = 20,
KSCAN    = 30,
KEMISS   = 40,
KCOSTLP  = 20,
KCOSTP   = 6,
KCHECK   = 0,
KSTART   = 0,
KSTOP    = 9999999999,
$END
```

(continued)

TABLE IV-14 (continued)

```
PRESET VALUES OF CONSTANTS AND INTERNAL TABLES
WHICH USER MAY OVERIDE BY NAMELIST INPUT
CONSTANTS

OPYEAR 2000.  CEINDX 160.2
CONS 1.05  RETRO 1.0 FLOCAT 1.0  RATE  .149
NACOST20.0 GRACE 0.000

PROCESS      START  INTYPE MAIN   INDR    PREMIS   SITEFAC
LIMESTONE     1.2     1.2   .08 1.35 1.41  1.2      1.00
LIME          1.2     1.2   .08 1.35 1.41  1.2      1.00
MAGNESIA      1.2     1.2   .07 1.37 1.43  1.2      1.00
SODIUM SOL    1.2     1.2   .06 1.37 1.43  1.2      1.00
CATL-OXDAT    1.2     1.2   .04 1.37 1.43  1.2      1.00
GYPSUM        1.2     1.2   .08 1.35 1.41  1.2      1.00

 USER OVERIDE SELECTIONS FOLLOW
$OVERIDE
OPYEAR   = .1983E+04,
CEINDX   = .3421E+03,
RATE     = .149E+00, .153E+00,
START    = .116E+01, .116E+01, .118E+01, .118E+01, .118E+01, .116E+01,
INTYPE   = .12E+01, .12E+01, .12E+01, .12E+01, .12E+01, .12E+01,
MAIN     = .8E-01, .8E-01, .7E-01, .6E-01, .4E-01, .8E-01,
INDR     = .135E+01, .135E+01, .137E+01, .137E+01, .137E+01, .135E+01,
           .141E+01, .141E+01, .143E+01, .143E+01, .143E+01, .141E+0,
NACOST   = .2E+02,
RETRO    = .1E+01,
FLOCAT   = .1E+01,
CONS     = .105E+01,
PREMIS   = .12E+01, .12E+01, .13E+01, .12E+01, .12E+01, .12E+01,
GRACE    = .1E+00,
SITEFAC  = .1E+01, .1E+01, .1E+01, .1E+01, .1E+01, .1E+01,
$END
```

TABLE IV-15. REPORT FORMAT FOR PLANT-LEVEL SCRUBBING COSTS

```
                COMPLIANCE COSTS FROM   1983  PROJECTIONS

PLANT CODE AND NAME    9990009910  FIRST PLANT
CAPACITY FACTOR COAL  .024  OIL 0.000  GAS 0.000
SULFUR CONTENT  COAL .0360  OIL .0010
TOTAL CAPACITY  1482.MW  TOTAL BOILERS  10
     SCRUBBED  1482.MW                  10
PROCESS             LIMESTONE      MAGNESIA       SODIUM         GYPSUM
INVESTMENTS
     $             162824358.    171467201.    187184073.    177983095.
    $/KW                109.9         115.7         126.3         120.1
FIRST YEAR COSTS
BYPRODUCT REVENUES
EXCLUDED
     $             139917800.    147558693.    167351951.    156772359.
  MIL/KWH               25.84         27.25         30.90         28.95
CENTS/MMBTU             245.8         259.2         294.0         275.4

BYPRODUCT             SLUDGE         H2SO4            S      CASO4.2H2O
TONS/YR              442226.       236820.        70988.        519555.
COST $/TON              316.4         623.1        2357.5         301.7

INCREMENTAL COSTS
IN COMPARISON TO
LIMESTONE PROCESS
     $                    0.      7640894.     27434151.      16854559.
    $/TON                 0.           32.          386.            32.
```

TABLE IV-16. REPORT FORMAT FOR THE EDIT OF USER-SUPPLIED POWER PLANT DATA

```
$PLANTIN
IFPC    = 4770004100,
BTUCOL  = .105358E+05,
BTUOIL  = .1375885E+06,
BTUGAS  = .1E+04,
SULCOL  = .37E-01,
SULOIL  = .2E-02,
HTRATE  = .98600128537E+04,
ISPLC   = 436270,
ISIP1   = 2,
ISIP2   = 1,
REGC    = 0.0,
ISIPO   = 0,
REGO    = 0.0,
PEDCO   = 0.0,
VLIME   = .442E+03,
SITEFAC = .1E+01, .1E+01, .1E+01, .1E+01, .1E+01, .1E+01,
$END

BOILER DATA
IB  YR  TOTCOL  TOTOIL  TOTGAS    AIR     CAPF GENCAP PSCR RETRO COLSIF COLVAL OILSIF OILVAL
 1  72  3089.3     0.0     0.0 2234600.  .580  1300.       1.140      7 500.00      0   4.00
 2  73  3010.7     0.0     0.0 2234600.  .565  1300.       1.140      3   4.00      0   4.00
```

TABLE IV-17. REPORT FORMAT FOR THE EDIT OF DATA BASE POWER PLANT DATA

```
*****9990009910***** CAP  .570**** POWER PLANT A                ****B
SULCOL BTUCOL SULOIL BTUOIL BTUGAS PEDCO VLIME          SITEFAC              COLSIP COLVAL OILSIP OILVAL
 .042  10268.  .002 136600.  1000.  0.00  0.00 1.00 1.00 1.00 1.00 1.00 1.00      0   0.00      0   0.00

BOILER DATA
IB  YR  TOTCOL  TOTOIL  TOTGAS   AIR    CAPF GENCAP PSCR RETRO COLSIP COLVAL OILSIP OILVAL
1   63  1514.4     0.0     0.0 1166120.  .531   704.      1.158      4   2.00      4   1.50
2   63  1514.4     0.0     0.0 1166120.  .531   704.      1.158      4   2.00      4   1.50
3   69  2871.3     0.0     0.0 1829000.  .617  1150.      1.158      4   2.00      4   1.50

*****9990009920***** CAP  .570**** POWER PLANT B                ****B
SULCOL BTUCOL SULOIL BTUOIL BTUGAS PEDCO VLIME          SITEFAC              COLSIP COLVAL OILSIP OILVAL
 .037  10536.  .002 137589.  1000.  0.00  0.00 1.00 1.00 1.00 1.00 1.00 1.00      0   0.00      0   0.00

BOILER DATA
IB  YR  TOTCOL  TOTOIL  TOTGAS   AIR    CAPF GENCAP PSCR RETRO COLSIP COLVAL OILSIP OILVAL
1   72  3050.0     0.0     0.0 2234600.  .572  1300.      1.140      3   4.00      3   4.00
2   73  3050.0     0.0     0.0 2234600.  .572  1300.      1.140      3   4.00      3   4.00
```

TABLE IV-18. REPORT FORMAT FOR BOILER SCRUBBING COSTS

```
LPFFCN        SPLC  S NB NGB NBS YEAR  SULCOL     BTUCOL    SULOIL      BTUOIL        BTUGAS
 105000100 536460  2  2   1   1 1983   .0250      9300.     .0050     136600.          985.

  BID      STARTUP      ACCHET         ACCSUL  LIMESTONE    MAGNESIA      GYPSUM    CFUEL    CAP DUCT     AIR      TOTCOL    TOTOIL  YEAR
  8       1659371.     1851816.         2290.   2776929.    3314939.    2521776.    1.500   .238  2.   175379.      99.6       0.0  1981

LPFFCN        SPLC  S NB NGB NBS YEAR  SULCOL     BTUCOL    SULOIL      BTUOIL        BTUGAS
 220000100 199526  1  1   1   1 1983   .0280     12800.     .0100     140000.         1000.

  BID      STARTUP      ACCHET         ACCSUL  LIMESTONE    MAGNESIA      GYPSUM    CFUEL    CAP DUCT     AIR      TOTCOL    TOTOIL  YEAR
  2       3528489.     8277215.         5387.   6037693.    8096447.    6397774.     .729   .578  2.   281225.     163.5     695.9  1964

LPFFCN        SPLC  S NB NGB NBS YEAR  SULCOL     BTUCOL    SULOIL      BTUOIL        BTUGAS
 265000050 236800  2  1   1   1 1983   .0350     12000.     .0050     144745.         1000.

  BID      STARTUP      ACCHET         ACCSUL  LIMESTONE    MAGNESIA      GYPSUM    CFUEL    CAP DUCT     AIR      TOTCOL    TOTOIL  YEAR
  1       6616406.    24767520.        33230.  15227548.   16752575.   15619522.     .615   .515  4.  1083360.    1032.0       0.0  1982

LPFFCN        SPLC  S NB NGB NBS YEAR  SULCOL     BTUCOL    SULOIL      BTUOIL        BTUGAS
 410000050 296118  1  3   3   3 1983   .0350     10550.     .0250     149000.         1000.

  BID      STARTUP      ACCHET         ACCSUL  LIMESTONE    MAGNESIA      GYPSUM    CFUEL    CAP DUCT     AIR      TOTCOL    TOTOIL  YEAR
  2       3537997.     9791033.        14942.   8311295.   11373632.    8900322.     .849   .650  2.   319222.     464.0       0.0  1970
  1       3595420.    19582066.        29884.  15538735.   20241354.   17100976.     .794   .650  2.   319222.     464.0       0.0  1969
  3       3755089.    29545908.        45089.  23012269.   28781268.   25459457.     .779   .650  2.   365333.     472.2       0.0  1972

LPFFCN        SPLC  S NB NGB NBS YEAR  SULCOL     BTUCOL    SULOIL      BTUOIL        BTUGAS
 410000100 296920  1  3   1   1 1983   .0370     10300.     .0010     136000.         1000.

  BID      STARTUP      ACCHET         ACCSUL  LIMESTONE    MAGNESIA      GYPSUM    CFUEL    CAP DUCT     AIR      TOTCOL    TOTOIL  YEAR
  1       2617317.     4811954.         7951.   5340665.    8160460.    5793009.    1.110   .596  2.   169666.     233.6       0.0  1965
```

TABLE IV-19. REPORT FORMAT FOR THE PLANT SCAN SUMMARY

```
 40000500 TOMBIGBEE                      NB= 3 NGB= 0 NBS= 0 SPLC=479442        COMP       NEW  PSCR
 45000200 BARRY                          NB= 2 NGB= 0 NBS= 0 SPLC=479916        COMP
 45000600 GORGAS                         NB= 1 NGB= 0 NBS= 0 SPLC=473763        COMP
 45000800 GREENE COUNTY                  NB= 2 NGB= 0 NBS= 0 SPLC=476917        COMP
105000100 AMES (IOWA)                    NB= 2 NGB= 1 NBS= 1 SPLC=536460                   NEW                 SCRB
140000800 AMOS                           NB= 3 NGB= 0 NBS= 0 SPLC=277620                                  SIP
140009910 MOUNTAINEER                    NB= 1 NGB= 0 NBS= 0 SPLC=277310        COMP       NEW
165000100 APACHE                         NB= 3 NGB= 0 NBS= 0 SPLC=795741        COMP       NEW  PSCR GAS
170000200 CHOLLA                         NB= 4 NGB= 0 NBS= 0 SPLC=791168        COMP       NEW  PSCR
170000300 FOUR CORNERS                   NB= 5 NGB= 0 NBS= 0 SPLC=783133                        PSCR      SIP
175000200 BAILEY                         NB= 1 NGB= 0 NBS= 0 SPLC=607150                                  SIP
175000300 MCCLELLAN                      NB= 1 NGB= 0 NBS= 0 SPLC=617450                                  SIP
185000500 LAKE CATHERINE                 NB= 1 NGB= 0 NBS= 0 SPLC=613150                                  SIP
185000600 RITCHIE                        NB= 1 NGB= 0 NBS= 0 SPLC=610430                                  SIP
185000800 WHITE BLUFF                    NB= 2 NGB= 0 NBS= 0 SPLC=611826        COMP       NEW
220000100 ENGLAND                        NB= 1 NGB= 1 NBS= 1 SPLC=199526                                       SCRB
265000050 BRANDON SHORES                 NB= 1 NGB= 1 NBS= 1 SPLC=236800                   NEW                 SCRB
265000100 CRANE                          NB= 1 NGB= 0 NBS= 0 SPLC=232314        COMP  GRAC           KOFF
265000300 WAGNER                         NB= 2 NGB= 0 NBS= 0 SPLC=234000        COMP
310000100 LELAND OLDS                    NB= 1 NGB= 0 NBS= 0 SPLC=516924        COMP
410000050 COLEMAN                        NB= 3 NGB= 3 NBS= 3 SPLC=296118                                       SCRB
410000100 REID                           NB= 3 NGB= 1 NBS= 1 SPLC=296920                   NEW  PSCR           SCRB
485000400 NEW BOSTON                     NB= 2 NGB= 0 NBS= 0 SPLC=142000        COMP
520000200 MILLER                         NB= 2 NGB= 0 NBS= 0 SPLC=668450        COMP                 GAS
627500100 BIG CAJUN                      NB= 2 NGB= 0 NBS= 0 SPLC=644450        COMP                 GAS
```

TABLE IV-20. REPORT FORMAT FOR EMISSIONS AND COMPLIANCE

```
***** EMISSION AND COMPLIANCE  ; FOR   45000800

PLANT SIP NB= 2 NBS= 0

REG-CD= 3 LBSO2/MMBTU COAL     4.00 OIL     4.00
TONS S/YR ALLOWED   28036.  EMITTED   26473.
 MMBTUS    28036058.          0.          0.
IB N/O    SUL    FRAC  MMBTUCOL      OIL       GAS        XSEMR  CD    REGC     REGO  ALLOWED
1   0   13737.-2.000 14547816.         0.         0.         0.
2   0   12736.-2.000 13488243.         0.         0.         0.

***** EMISSION AND COMPLIANCE  ; FOR  105000100

PLANT SIP NB= 2 NBS= 1

REG-CD= 4 LBSO2/MMBTU COAL     5.00 OIL     2.50
TONS S/YR ALLOWED     556.  EMITTED    2290.
 MMBTUS      1851816.         0.          0.
IB N/O    SUL    FRAC  MMBTUCOL      OIL       GAS        XSEMR  CD    REGC     REGO  ALLOWED
7   0    1620.-2.000  1310184.         0.         0.         0.
8   N    2290.  .842  1851816.         0.         0.       327. 4     1.20      .80     556.

***** EMISSION AND COMPLIANCE  ; FOR  220000100

BOILER SIP NB= 1 NBS= 1

IB N/O    SUL    FRAC  MMBTUCOL      OIL       GAS        XSEMR  CD    REGC     REGO  ALLOWED
2   0    5387.  .707  4185088.  4092127.          0.      1422. 2     1.56      .32    1960.

***** EMISSION AND COMPLIANCE  ; FOR  410000050

BOILER SIP NB= 3 NBS= 3

IB N/O    SUL    FRAC  MMBTUCOL      OIL       GAS        XSEMR  CD    REGC     REGO  ALLOWED
1   0   14942.  .747  9791033.         0.         0.      3401. 4     2.00     1.50    4896.
2   0   14942.  .747  9791033.         0.         0.      3401. 4     2.00     1.50    4896.
3   0   15205.  .747  9963842.         0.         0.      3461. 4     2.00     1.50    4982.
```

TABLE IV-21. REPORT FORMAT FOR THE EMISSIONS SUMMARY

```
              EMISSION AND ABATEMENT SUMMARY

REGION   NPLT NBLR EMISSIONS   NPC NPS  NBS  REMOVED    EXCESS

EASTERN    22   38   309939.    12   5    7   84552.    17730.

WESTERN     3   12    30060.     2   0    0       0.        0.

TOTAL      25   50   339999.    14   5    7   84552.    17730.
```

TABLE IV-22. REPORT FORMAT FOR THE EDIT OF SCRUBBER

INVESTMENT AND OPERATING FACTORS

```
          EDIT OF  CURRENT SASDATA AND PRICES

LIMESTONE  PROCESS FOR     NEW    BOILER SUL=39848.  AIR=  888000.
 FOR YEAR  1978.  CEINDX   214.7

ISEQ (K)   AREA     (L)   ITEM       QTY/AMT     RATE      COST    **SUL  **AIR
  10   1 RAW  MATL   1 CAPITAL       419000.     0.00    561544.    .650  0.000
  20   1            10 LIMESTONE     175000.     6.00   1050000.   1.000  0.000
  30   1             2 LABOR           4170.    10.00     41700.    .436  0.000
  40   1             8 ELECTRICTY    390000.      .03     10530.   1.000  0.000
  50   1            21 ANALYSES        1520.    15.00     22800.    .731  0.000
  60   2 FEED PREP   1 CAPITAL       899000.     0.00   1204840.    .720  0.000
  70   2             2 LABOR           6470.    10.00     64700.    .436  0.000
  80   2             8 ELECTRICTY   5150000.      .03    139050.   1.000  0.000
 130   4 SO2  SCRUB  1 CAPITAL      4655000.     0.00   6238630.   0.000   .740
 140   4             2 LABOR           4900.    10.00     49000.    .436  0.000
 150   4             7 PROC WATER    174700.      .06     10482.   0.000  1.000
 160   4             8 ELECTRICTY  22530000.      .03    608310.   0.000  1.000
 170   4            21 ANALYSES        1140.    15.00     17100.    .731  0.000
 180   5 REHEAT      1 CAPITAL       585000.     0.00    784017.   0.000   .680
 190   5             2 LABOR           1250.    10.00     12500.    .436  0.000
 200   5             6 STEAM 500     557800.     1.40    780920.   0.000  1.000
 210   6 FANS        1 CAPITAL       544000.     0.00    729069.   0.000   .630
 220   6             2 LABOR           1250.    10.00     12500.    .436  0.000
 230   6             8 ELECTRICTY  26511000.      .03    715797.   0.000  1.000
 240   7 CAL SOLIDS  1 CAPITAL      3923000.     0.00   5257604.    .610  0.000
 250   7             2 LABOR           3340.    10.00     33400.    .436  0.000
 260   7             7 PROC WATER     75600.      .06      4536.   1.000  0.000
 270   7             8 ELECTRICTY    700000.      .03     18900.   1.000  0.000
 280   7            21 ANALYSES         380.    15.00      5700.    .731  0.000
 281   8 OFFSITE CH  1 CAPITAL      4133700.     0.00   5539984.    .610  0.000
 282   8             7 PROC WATER     49600.      .06      2976.   1.000  0.000
 283   8             8 ELECTRICTY    888000.      .03     23976.   1.000  0.000
 284   8            24 DISPOSAL      412000.     1.00    412000.   1.000  0.000
 290  12 UTILITIES   1 CAPITAL        67000.     0.00     89793.   0.000   .430
 300  12             8 ELECTRICTY    230000.      .03      6210.   0.000  1.000
 310  13 SERVICES    1 CAPITAL       638000.     0.00    855047.   0.000   .370
 320  13             8 ELECTRICTY    220000.      .03      5940.   0.000  1.000
```

TABLE IV-23. REPORT FORMAT FOR DETAILED SCRUBBING COSTS

```
 DETAILED COSTS FOR BOILER   1.

INPUT DATA SUL=   105159. AIR=  2234600. DUC=4.0 CAP= .580
SUMSUL=   105159.  STRTYR=1972.

LIMESTONE  PROCESS  CAPITAL     INVESTMENT-COSTS
SCALED  RAW  MATL  INVESTMENT   787317.  COMMON FACILITIES   787317.
SCALED  FEED PREP  INVESTMENT  1807990.  COMMON FACILITIES  1807990.
SCALED  SO2  SCRUB INVESTMENT  9215140.  COMMON FACILITIES        0.
SCALED  REHEAT     INVESTMENT  1095698.  COMMON FACILITIES        0.
SCALED  FANS       INVESTMENT   972959.  COMMON FACILITIES        0.
SCALED  CAL SOLIDS INVESTMENT  6705226.  COMMON FACILITIES  6705226.
SCALED  UTILITIES  INVESTMENT    99635.  COMMON FACILITIES        0.
SCALED  SERVICES   INVESTMENT   897660.  COMMON FACILITIES        0.
*UNADJUSTED TOTAL  INVESTMENT 21581625.  COMMON FACILITIES  9300533.
TINVEST=UAJ*CONS*CEINDX/160.2 65061015.COST= TINVEST*.3363=13973112.

   COSTS FOR LABOR
SCALED RAW  MATL  COST=    54193.ACCUM    54193.
SCALED FEED PREP  COST=    84083.ACCUM   138276.
SCALED SO2  SCRUB COST=    63680.ACCUM   201955.
SCALED REHEAT     COST=    16245.ACCUM   218200.
SCALED FANS       COST=    16245.ACCUM   234445.
SCALED CAL SOLIDS COST=    43406.ACCUM   277851.
OVERHEAD ADJ 1.3                 ADJCST   361206.  TOT-CST 14334318.

   COSTS FOR STEAM 500
SCALED REHEAT     COST=  1423989.ACCUM  1423989.
OVERHEAD ADJ 1.2                 ADJCST  1708787.  TOT-CST 16043105.

   COSTS FOR PROC WATER
SCALED SO2  SCRUB COST=    19114.ACCUM    19114.
SCALED CAL SOLIDS COST=     8674.ACCUM    27788.
OVERHEAD ADJ 1.2                 ADJCST    33345.  TOT-CST 16076451.
```

(continued)

TABLE IV-23 (continued)

```
   COSTS FOR ELECTRICTY
SCALED RAW  MATL  COST=    20136.ACCUM    20136.
SCALED FEED PREP  COST=   265903.ACCUM   286040.
SCALED SO2  SCRUB COST=  1109239.ACCUM  1395279.
SCALED FANS       COST=  1305239.ACCUM  2700517.
SCALED CAL SOLIDS COST=    36142.ACCUM  2736660.
SCALED UTILITIES  COST=    11324.ACCUM  2747983.
SCALED SERVICES   COST=    10831.ACCUM  2758815.
OVERHEAD ADJ 1.2                 ADJCST 3310578.  TOT-CST 19387028.

   COSTS FOR LIMESTONE
SCALED RAW  MATL  COST=  1479153.ACCUM  1479153.
OVERHEAD ADJ 1.0                 ADJCST 1479153.  TOT-CST 20866181.

   COSTS FOR ANALYSES
SCALED RAW  MATL  COST=    33583.ACCUM    33583.
SCALED SO2  SCRUB COST=    25187.ACCUM    58770.
SCALED CAL SOLIDS COST=     8396.ACCUM    67166.
OVERHEAD ADJ 1.2                 ADJCST   80599.  TOT-CST 20946780.


  DETAILED COSTS FOR BOILER   2

INPUT DATA SUL=   102485. AIR=  2234600. DUC=4.0 CAP= .565
SUMSUL=   102485.  STRTYR=1973.

SODIUM SOL PROCESS  CAPITAL     INVESTMENT-COSTS
SCALED  RAW  MATL  INVESTMENT   404148.  COMMON FACILITIES   404148.
SCALED  SO2  SCRUB INVESTMENT  8874612.  COMMON FACILITIES        0.
SCALED  REHEAT     INVESTMENT  1260525.  COMMON FACILITIES        0.
SCALED  FANS       INVESTMENT  1046289.  COMMON FACILITIES        0.
SCALED  PURGE      INVESTMENT  2670936.  COMMON FACILITIES  2670936.
SCALED  SO2  REGEN INVESTMENT  5263423.  COMMON FACILITIES  5263423.
SCALED  SO2  REDUC INVESTMENT  4911022.  COMMON FACILITIES  4911022.
SCALED  SULFUR STR INVESTMENT   431518.  COMMON FACILITIES   431518.
SCALED  UTILITIES  INVESTMENT   309334.  COMMON FACILITIES        0.
SCALED  SERVICES   INVESTMENT   940063.  COMMON FACILITIES        0.
*UNADJUSTED TOTAL  INVESTMENT 26111871.  COMMON FACILITIES 13681048.
TINVEST=UAJ*CONS*CEINDX/160.2 81261624.COST= TINVEST*.3185=16011621.
```

(continued)

TABLE IV-23 (continued)

```
   COSTS FOR LABOR
SCALED RAW  MATL  COST=     33957.ACCUM    33957.
SCALED SO2  SCRUB COST=     51408.ACCUM    85364.
SCALED REHEAT     COST=     10782.ACCUM    96146.
SCALED FANS       COST=     10782.ACCUM   106928.
SCALED PURGE      COST=    108206.ACCUM   215133.
SCALED SO2  REGEN COST=    108206.ACCUM   323339.
SCALED SO2  REDUC COST=    108206.ACCUM   431545.
SCALED SULFUR STR COST=     33901.ACCUM   465446.
OVERHEAD ADJ 1.3                  ADJCST  605080.  TOT-CST 16616702.

   COSTS FOR NATURL GAS
SCALED SO2  REDUC COST=   2313651.ACCUM  2313651.
OVERHEAD ADJ 1.2                  ADJCST 2776381.  TOT-CST 19393083.

   COSTS FOR STEAM 500
SCALED REHEAT     COST=   1160962.ACCUM  1160962.
SCALED PURGE      COST=    363136.ACCUM  1524099.
SCALED SO2  REGEN COST=   4005182.ACCUM  5529281.
OVERHEAD ADJ 1.2                  ADJCST 6635137.  TOT-CST 26028219.

   COSTS FOR PROC WATER
SCALED RAW  MATL  COST=       970.ACCUM      970.
SCALED PURGE      COST=     35562.ACCUM    36532.
SCALED SO2  REGEN COST=   1029740.ACCUM  1066272.
OVERHEAD ADJ 1.2                  ADJCST 1279526.  TOT-CST 27307746.

   COSTS FOR ELECTRICTY
SCALED RAW  MATL  COST=     22069.ACCUM    22069.
SCALED SO2  SCRUB COST=    107007.ACCUM   129077.
SCALED FANS       COST=   1351653.ACCUM  1480729.
SCALED PURGE      COST=    318780.ACCUM  1799509.
SCALED SO2  REGEN COST=    573804.ACCUM  2373313.
SCALED SO2  REDUC COST=    101519.ACCUM  2474832.
SCALED SULFUR STR COST=      8337.ACCUM  2483169.
SCALED UTILITIES  COST=     11037.ACCUM  2494206.
SCALED SERVICES   COST=     11996.ACCUM  2506202.
OVERHEAD ADJ 1.2                  ADJCST 3007443.  TOT-CST 30315188.
```

(continued)

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TABLE IV-23 (continued)

```
   COSTS FOR HT CREDIT
SCALED SO2  REDUC COST=  -131390.ACCUM  -131390.
OVERHEAD ADJ 1.2                ADJCST  -157668.  TOT-CST 30157520.

   COSTS FOR LIME (NA )
SCALED RAW  MATL  COST=   10223.ACCUM    10223.
OVERHEAD ADJ 1.0                ADJCST    10223.  TOT-CST 30167743.

   COSTS FOR VAPNT CAT
SCALED RAW  MATL  COST=   29060.ACCUM    29060.
OVERHEAD ADJ 1.0                ADJCST    29060.  TOT-CST 30196803.

   COSTS FOR SODIUM CBN
SCALED RAW  MATL  COST= 1317623.ACCUM  1317623.
OVERHEAD ADJ 1.0                ADJCST  1317623.  TOT-CST 31514426.

   COSTS FOR ANTI-OX-NA
SCALED RAW  MATL  COST= 1583954.ACCUM  1583954.
OVERHEAD ADJ 1.0                ADJCST  1583954.  TOT-CST 33098380.

   COSTS FOR ANALYSES
SCALED RAW  MATL  COST=   13563.ACCUM    13563.
SCALED SO2  SCRUB COST=   24159.ACCUM    37722.
SCALED PURGE      COST=   42384.ACCUM    80107.
SCALED SO2  REGEN COST=   26914.ACCUM   107021.
SCALED SO2  REDUC COST=   58279.ACCUM   165300.
SCALED SULFUR STR COST=   12715.ACCUM   178015.
OVERHEAD ADJ 1.2                ADJCST   213618.  TOT-CST 33311998.
```

DEMAND SUBSYSTEM

Data files used in the demand subsystem are listed in Table IV-24. Examples of the files not previously described and applicable printed reports are shown in Tables IV-25 through IV-33. Binary files are described.

TABLE IV-24. FILES USED IN DEMAND SUBSYSTEM

File name	Description
ACDPAR	Acid plant avoidable production cost factors (input to GENACD)
SACDSML	Acid plant and smelter data (input to ACDUPDT)
SULTER	Molten sulfur terminals (input to ACDUPDT)
ACDSML	Same as SACDSML above, with delivered sulfur costs added (output from ACDUPDT, input to GENACD)
ACDCST	Calculated avoidable production costs for sulfuric acid (output from GENACD, input to manual procedure in transportation subsystem, input to GENPGM and REPTSOL in linear programing subsystem)
SMLCST	Calculated production costs for smelters (output from GENACD, input to manual procedure in transportation subsystem, input to GENPGM and REPTSOL in linear programing subsystem)
RBNSORT	NRBT rate basing point data (required to add new sulfur terminals or acid plants, input to the manual procedure in the transportation subsystem)
RAILWA	Rail mileages between all possible combinations of NRBT rate basing points (input to ACDUPDT, input to TRNCOST in transportation subsystem)
X313SUL	Molten sulfur tariff data (input to ACDUPDT)

TABLE IV-25. FILE FORMAT FOR SULFURIC ACID AVOIDABLE PRODUCTION COST FACTORS (ACDPAR)

Number	Description	Format
1	Tons of sulfur per ton sulfuric acid (before year 60)	Free form
2	Tons of sulfur per ton sulfuric acid (after year 60)	Free form
3	Year of technology change	Free form
4	Sulfuric acid plant investment ($/ton/yr)	Free form
5	Capacity for base case plant (Mtons/yr)	Free form
6	Scale factor for determining investment for other sized plants	Free form
7	Variable conversion cost per ton ($/ton)	Free form
8	Fixed annual conversion cost ($/yr)	Free form
9	Taxes and insurance rate	Free form
10	Time preference rate for money	Free form
11	Compound maintenance rate	Free form
12	Economic useful life	Free form
13	Percent sulfuric acid concentration	Free form
14	Port Sulphur price ($/short ton)	Free form
15	TVA sulfuric acid price ($/ton)	Free form
16	Proportion of 330 TPD capacity estimate	Free form
17	Not used	Free form
18	Not used	Free form
19	Number of years considered	Free form
20	Years considered	Free form
21	Unit cost inflation factor	Free form
22	Transportation cost inflation factor for sulfur	Free form

TABLE IV-26. FILE FORMAT FOR ACID PLANT AND SMELTER DATA (SACDSML)

Field number	Description	Format
1	Acid plant sequence number	I3
2	Not used	1X
3	Acid plant name	2A10
4	Not used	1X
5	Acid plant location	A10,A5
6	SPLC	I5
7	SPLC for rate basis location	A6
8	Rate basis location	A10, A5
9	Rate basis index	I4
10	Tariff index (MES)	I2
11	Year plant built	A2
12	Plant capacity (1000 tons/year)	A4
13	Days operated	A3
14	Not used	A1
15	Latitude	A5
16	Longitude	A5
17	Not used	I4
18	Not used	I4
19	Not used	I4
20	Not used	I3
21	Percent sludge acid used	A4
22	CDS compliance code	A2
23	TVA plant status code	I3
24	Not used	I3

TABLE IV-27. FILE FORMAT FOR SULFUR TERMINAL DATA (SULTER)

Field number	Description	Format
1	Sulfur terminal SPLC	I6
2	Rail miles index	I4
3	Barge mode index	A10
4	Rail tariff index (MES)	I2
5	Barge rate	F5.2
6	Terminal type	A2
7	Rate estimation flag	A1
8	Statute miles from Port Sulphur to sulfur terminal	A4
9	Sulfur terminal location	2A10,A1
10	Rate basis location	A10,A5
11	Sulfur terminal handling charge	F5.2

TABLE IV-28. FILE FORMAT FOR ACID PLANT AND SMELTER DATA WITH DELIVERED COSTS OF MOLTEN SULFUR INCLUDED (ACDSML)

Field number	Description	Format
1	Acid plant sequence number	I3
2	Not used	1X
3	Acid plant name	2A10
4	Not used	1X
5	Acid plant location	A10,A5
6	SPLC	I5
7	SPLC for rate basis location	A6
8	Rate basis location	A10,A5
9	Rate basis index	I4
10	Tariff index (MES)	I2
11	Year plant built	A2
12	Plant capacity (1000 tons/year)	A4
13	Days operated	A3
14	Not used	A1
15	Latitude	A5
16	Longitude	A5
17	Unit cost of delivered sulfur	I4
18	Unit Port Sulphur barge rate to sulfur terminal	I4
19	Unit rail rate for sulfur terminal to acid plant	I4
20	Unit handling charge for sulfur terminal	I3
21	Percent sludge acid used	A4
22	CDS compliance code	A2
23	TVA plant status code	I3
24	Sulfur terminal index	I3

TABLE IV-29. REPORT FORMAT FOR DELIVERED SULFUR COSTS TO ACID PLANTS

```
ACID PLANT     1AGRICO CHEM-WILLIAMS        SULFUR TERMINAL NO.     5  FLTAMPA
OLD PORT SULFUR RATE = 10.21  NEW RATE = 10.22 (  5.80+  3.35+  1.07)

ACID PLANT     2AGRICO CHEM-WILLIAMS        SULFUR TERMINAL NO.    14  LAPORT SULPHUR
OLD PORT SULFUR RATE = 10.26  NEW RATE =  9.61 (  7.40+  0.00+  2.21)

ACID PLANT     7ALLIED CHEMICAL CORP        SULFUR TERMINAL NO.    11  LABATON ROUGE
OLD PORT SULFUR RATE =  9.66  NEW RATE =  9.41 (  5.20+  2.00+  2.21)

ACID PLANT    10ALLIED CHEMICAL CORP        SULFUR TERMINAL NO.    40  VARICHMOND
OLD PORT SULFUR RATE = 22.16  NEW RATE = 20.65 ( 12.80+  6.78+  1.07)

ACID PLANT    11ALLIED CHEMICAL CORP        SULFUR TERMINAL NO.    40  VARICHMOND
OLD PORT SULFUR RATE = 13.44  NEW RATE = 13.45 (  5.60+  6.78+  1.07)

ACID PLANT    13ALLIED CHEMICAL CORP        SULFUR TERMINAL NO.    17  MDBALTIMORE
OLD PORT SULFUR RATE = 16.34  NEW RATE = 16.35 (  8.40+  6.88+  1.07)

ACID PLANT    15AMERICAN CYANAMID           SULFUR TERMINAL NO.    26  NJSAYREVILLE
OLD PORT SULFUR RATE = 13.79  NEW RATE = 13.73 (  5.60+  7.06+  1.07)

ACID PLANT    16AMERICAN CYANAMID           SULFUR TERMINAL NO.    19  MSPASCAGOULA
OLD PORT SULFUR RATE =  9.85  NEW RATE =  9.59 (  5.60+  1.78+  2.21)

ACID PLANT    17AMERICAN CYANAMID           SULFUR TERMINAL NO.     8  ILJOLIET
OLD PORT SULFUR RATE = 22.41  NEW RATE = 22.16 (  5.60+ 14.35+  2.21)

ACID PLANT    18AMERICAN CYANAMID           SULFUR TERMINAL NO.     6  GASAVANNAH
OLD PORT SULFUR RATE = 11.62  NEW RATE = 11.63 (  5.20+  5.36+  1.07)
```

TABLE IV-30. FILE FORMAT FOR SULFURIC ACID AVOIDABLE PRODUCTION COSTS AND RELATED QUANTITIES (ACDCST)

Field number	Description	Format
1	Acid plant sequence number	I3
2	Acid plant name	2A10
3	Acid plant location	A10,A6
4	SPLC	I6
5	Unit production cost of sulfuric acid using elemental sulfur (Port Sulphur)	F10.2
6	Sulfuric acid plant production	F10

TABLE IV-31. FILE FORMAT FOR SMELTER PRODUCTION COSTS AND RELATED QUANTITIES (SMLCST)

Field number	Description	Format
1	Pseudo FPC code	I10
2	Smelter name	2A10
3	Smelter location	A10,A6
4	SPLC	I6
5	Unit production cost of sulfuric acid	F10.0
6	Sulfuric acid production	F10.0

TABLE IV-32. FILE FORMAT FOR RAIL RATE BASING POINT LOCATION DATA (RBNSORT)

Field number	Description	Format
1	State abbreviation	A2
2	Rate basing point name	2A10,A7
3	Rate basis SPLC	I6
4	Rail mileage index	I4
5	Tariff table index	I2

TABLE IV-33. REPORT FORMATS FOR SULFURIC ACID

AVOIDABLE PRODUCTION COSTS

```
                        REPORT 1

          SULFURIC ACID PLANTS CONSIDERED

                                                      ANNUAL
#   NAME                      LOCATION          YEAR  CAPACITY

 1. AGRICO CHEM-WILLIAMS    PIERCE       FL     1975     900
 2. AGRICO CHEM-WILLIAMS    DONALDSONVL  LA     1975     900
 7. ALLIED CHEMICAL CORP    GEISMAR      LA     1968     375
10. ALLIED CHEMICAL CORP    NITRO        WV     1940     101
11. ALLIED CHEMICAL CORP    HOPEWELL     VA     1965     150
13. ALLIED CHEMICAL CORP    FRONT ROYAL  VA     1945     120
15. AMERICAN CYANAMID       BOUND BROOK  NJ     1945      48
16. AMERICAN CYANAMID       MOBILE       AL     1967      19
17. AMERICAN CYANAMID       JOLIET       IL     1937      37
18. AMERICAN CYANAMID       SAVANNAH     GA     1967     162

TOTAL ACID CAPACITY IS    2812


                          REPORT 2

                 SULFUR FREIGHT RATES

                      PORT SULFUR RATES
#LOCATION               TOTAL    BARG    RAIL   HANDLING


 1. PIERCE       FL     22.05    5.79    3.34     1.07
 2. DONALDSONVL  LA     20.74    7.40    0.00     2.20
 7. GEISMAR      LA     20.30    5.19    2.00     2.20
10. NITRO        WV     44.58   12.80    6.77     1.07
11. HOPEWELL     VA     29.03    5.59    6.77     1.07
13. FRONT ROYAL  VA     35.29    8.39    6.87     1.07
15. BOUND BROOK  NJ     29.66    5.59    7.06     1.07
16. MOBILE       AL     20.69    5.59    1.78     2.20
17. JOLIET       IL     47.84    5.59   14.35     2.20
18. SAVANNAH     GA     25.10    5.19    5.35     1.07
```

(continued)

TABLE IV-33 (continued)

```
REPORT 3


SULFUR PRICE F.O.B.                       62.50
BASE YEAR                                  1983
INVESTMENT RATE                             .10
MAINTENANCE RATE                            .05
UNIT COST INFLATION FACTOR-NEW             1.00
UNIT COST INFLATION FACTOR-OLD             1.00
TRANSPORTATION INFLATION FACTOR            2.16


        SULFURIC ACID PRODUCTION COSTS

                          SULFUR  CONVERSION - RETRO - TOTAL COSTS
#   LOCATION              FACTOR          1983

 1. PIERCE        FL       .3282      -3.18     0.00    24.57
 2. DONALDSONVL   LA       .3282      -3.18     3.04    27.18
 7. GEISMAR       LA       .3282      -1.10     0.00    26.07
10. NITRO         WV       .3282       3.69     0.00    38.83
11. HOPEWELL      VA       .3282       1.42     5.10    36.56
13. FRONT ROYAL   VA       .3282       3.11     0.00    35.21
15. BOUND BROOK   NJ       .3282       6.61     7.06    43.91
16. MOBILE        AL       .3282       8.76     0.00    36.06
17. JOLIET        IL       .3282       7.86     0.00    44.07
18. SAVANNAH      GA       .3282        .86     0.00    29.61
19. KALAMAZOO     MI       .3282       8.97     0.00    47.06
```

Rail Mileage File (RAILWA)

The RAILWA file contains rail mileages between 2632 rate basis locations published for the various tariff associations. The file is binary so a specific file format is not provided; listing of the data as stored is not meaningful.

A detailed narrative of the design and development of the rail mileage file is provided in Appendix C because of its potential use in applications other than the byproduct marketing system. The file can be used to determine rail mileages for various purposes such as finding all rate basing locations within a specified distance by rail from a given location, the distance from several rate basing points to other rate basing points including all other points if required, etc.

Sulfur Tariff File (X313SUL)

The X313SUL file contains tariff rates for shipping sulfur by rail with individual rates dependent upon the distance to be shipped. The file as used in the system is binary and because of the coding technique used a simple listing of the file is not particularly useful. A binary data file was used because the tariff rates for sulfur were taken from a generalized structure of rail rates (both class rates and commodity rates) where the conservation of memory and storage as well as efficient data access were necessary (see also the sulfuric acid tariff file). Processing of the data requires a program such as ACDUPDT (described in section III). The source program listing can be used to examine the exact procedures but the coding details are not necessary for use of the system.

Conceptually, the tariff structure can be thought of as a table or array with the columns representing the various commodities shipped and the rows representing the exact shipping rate per commodity, one row for each distance specified in the tariff. When several tariffs are applicable, a separate table or array can be used. Using the concept of tariff tables, a knowledge of the source, destination, commodity, and distance to be shipped allows the selection of the appropriate table (array), column, and row, respectively, that contains the applicable rate value.

Because the sulfur tariff is a class tariff the process is greatly simplified. Only one tariff applies; therefore only a single table is required for sulfur shipping rates.

TRANSPORTATION SUBSYSTEM

Data files used in the transportation subsystem are shown in Table IV-34. The file format for TRNPTS (the only nonbinary file not previously described) is shown in Table IV-35.

TABLE IV-34. FILES USED IN TRANSPORTATION SUBSYSTEM

File name	Description
RAILWA[a]	Rail mileages between all possible combinations of NRBT rate basing points (input to ACDUPDT in the demand subsystem, input to TRNCOST)
SCRCST[b]	Boiler scrubbing costs and emissions data (output from STMCAP in the supply subsystem, input to the manual procedure, input to GENPGM in the linear programing subsystem)
ACDCST[a]	Calculated avoidable production costs for sulfuric acid (output from GENACD in the demand subsystem, input to the manual procedure, input to GENPGM and REPTSOL in the linear programing subsystem)
SMLCST[a]	Calculated production costs for smelters (output from GENACD in the demand subsystem, input to the manual procedure, input to GENPGM and REPTSOL in the linear programing subsystem)
RBNSORT[a]	NRBT rate basing point data (input to the manual procedure, required in the demand subsystem to add sulfur terminals)
TRNPTS	Power plants, acid plants, smelters, and transshipment terminals with the appropriate location data (output from the manual procedure, input to TRNCOST)
X313H2S	Sulfuric acid tariff data (input to TRNCOST)
TRNCST	Transportation costs from potential supply points to potential demand points (output from TRNCOST, input to GENPGM in the linear programing subsystem)

a. Described in the preceding demand subsystem file descriptions.
b. Described in the preceding supply subsystem file descriptions.

TABLE IV-35. FILE FORMAT FOR TRANSPORTATION POINTS TO BE USED FOR SHIPPING RATE CALCULATIONS (TRNPTS)

Field number	Description	Format
Demand Section (acid plants)		
1	Identification code	I3
2	Location	I6
3	Miles to rail	I5
4	Rate basis SPLC	I6
5	Rail mileage index (rate basing point number)	I4
6	Tariff table index	I2
7	Miles to barge	I5
8	Barge node index	A10
9	Miles to Cairo	I5
10	Miles to Harvey Locks	I5
Supply Section (power plants, smelters, and transshipment terminals)		
1	Identification code	I10
2-10	As shown above	

Sulfuric Acid Tariff File (X313H2S)

The X313H2S file contains tariff rates for shipping sulfuric acid by rail with individual rates dependent on the source and destination points and the distance to be shipped. The file as used in the system is binary, and because of the coding techniques used a simple listing of the file is not particularly useful. A binary data file was used because the tariff rates for sulfuric acid were taken from a generalized structure of rail rates (both class rates and commodity rates) where the conservation of memory and storage as well as efficient data access were necessary (see also the sulfur tariff file). Processing of the data requires a program such as TRNCOST (described in section III). The source program listing can be used to examine the exact procedures, but the coding details are not necessary for use of the system.

Conceptually, the tariff structure can be thought of as a table or array with the columns representing the various commodities shipped and the rows representing the exact shipping rate per commodity, one row for each distance specified in the tariff. When several tariffs are applicable, a separate table for each must be used.

Using the concept of tariff tables, knowledge of the tariff that applies, the commodity, and the distance to be shipped allows the selection of the appropriate array, column, and row, respectively, in which the rate value that applies is entered. Because the sulfuric acid tariff is a commodity tariff, the tariff rate that applies not only depends on the distance to be shipped but also on the source and destination location of the shipment; therefore multiple tables are required for various source and destination combinations. The sample tariff table numbers shown in Table IV-36 illustrate the organization to allow determination of the appropriate table (array) based upon source and destination locations within the Docket 28300 territory. A map is also provided in Figure IV-2.

Transportation Cost File (TRNCST)

The TRNCST file is generated by the TRNCOST program for locations in the TRNPTS file and is used in the GENPGM program. The file is word addressable and randomly indexed. The index key is the supply point identification code. The file contains one record per potential supply point and each record contains 200 entries, 1 entry for each potential demand point to be considered. The file is binary so a direct listing of the file is not meaningful. The source program listings of the creating program (TRNCOST) or the accessing program (GENPGM) can be referenced if required but is not necessary to use the system. The actual values were built during the rate selection procedure. Each entry contains the following data:

1. The supply point index to the tariff tables
2. The demand point index to the tariff tables
3. The tariff table used
4. The rail mileage between the supply point and demand point
5. The rail rate between the supply point and demand point

TABLE IV-36. SAMPLE TARIFF TABLE DEFINITIONS

FOR THE ICC DOCKET 28300 TERRITORY

Tariff table number	Tariff series	Application
1	WTL W-1000	Between stations within WTL territory
2	WTL W/S-1001	Between stations in WTL and Southern territory
3	IFA I-1002	Between stations within IFA territory
4	IFA I/S-1003	Between stations in IFA and Southern territory
5	SWL SW-1004	Between stations with Southwestern territory
6	SWL SW/E-1005	Between stations in Southwestern and Official territory
7	SWL SW/W-1006	Between stations in Southwestern and WTL territory
8	SWL SW/S-1007	Between stations in Southwestern and Southern territory
9	TL E/S-1008	Between stations in Official (except Illinois) and Southern territory
10	TL-CTR E-1009	Between stations within New England, Trunkline, and CTR and between those stations and IFA territory
11	CTR E/W-1010	Between stations in Official and WTL territory
12	SFTB S-1011	Between stations within Southern territory

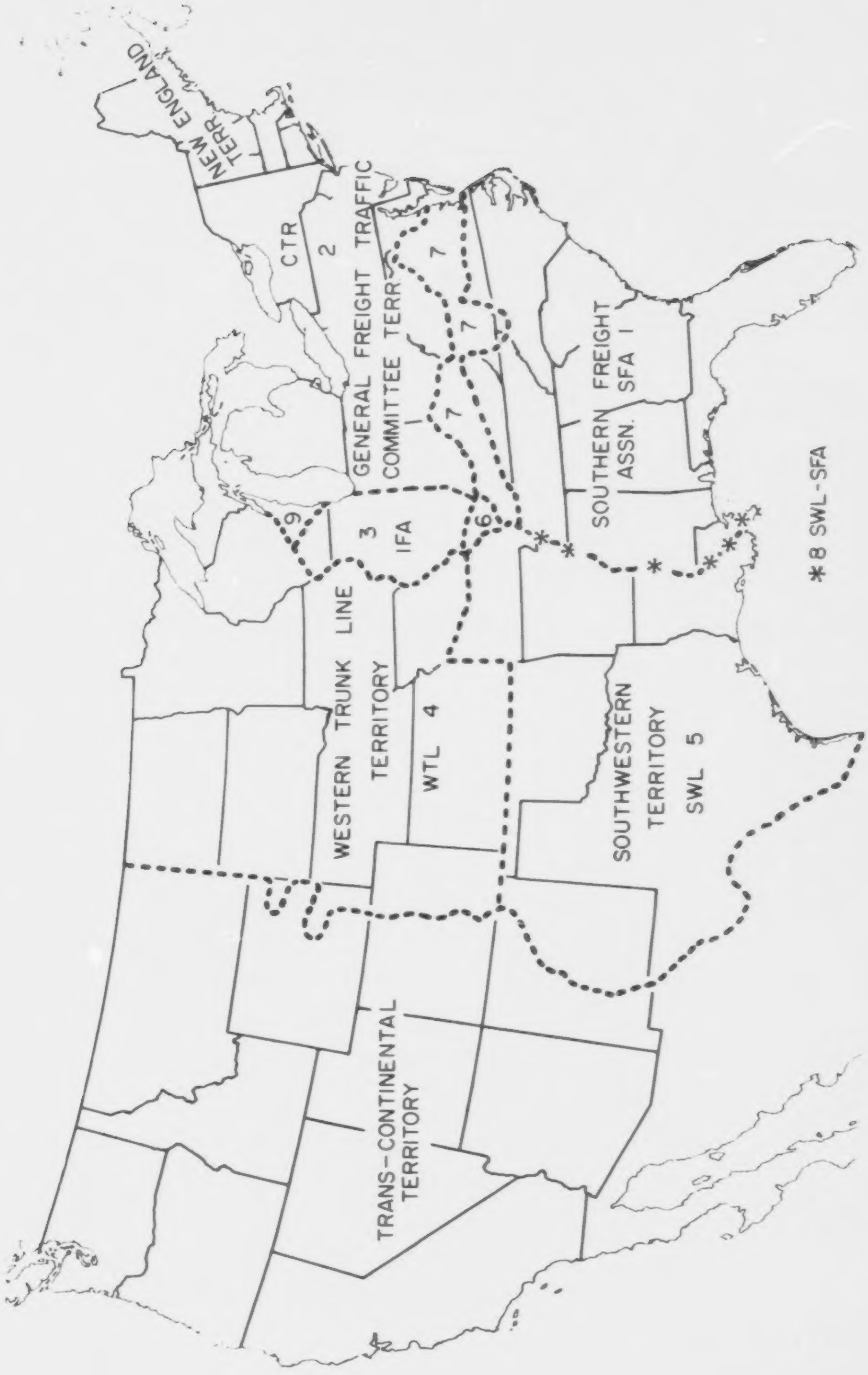

NEW ENGLAND TERR.
CTR
2
GENERAL FREIGHT TRAFFIC COMMITTEE TERR.
7
7
7
9
3
IFA
6
SOUTHERN FREIGHT ASSN.
SFA 1
WESTERN TRUNK LINE TERRITORY
WTL 4
SOUTHWESTERN TERRITORY
SWL 5
*8 SWL-SFA
TRANS-CONTINENTAL TERRITORY

Figure IV-2. Railroad rate territories.

LINEAR PROGRAMING SUBSYSTEM

Data files used in the linear programing subsystem are listed in Table IV-37. The only nonbinary file required for system executions and not previously described is shown in Table IV-38. Table IV-39 illustrates a printed report from the model generator program. Table IV-40 illustrates a final report of the model solution. Binary files are described.

TABLE IV-37. FILES USED IN THE LINEAR PROGRAMING SUBSYSTEM

File name	Description
SCRCST[a]	Boiler scrubbing costs and emissions data (output from STMCAP in the supply subsystem, input to the manual procedure in the transportation subsystem, input to GENPGM)
SMLCST[b]	Calculated production costs for smelters (output from GENACD in the demand subsystem, input to the manual procedure in the transportation subsystem, input to GENPGM and REPTSOL)
ACDCST[b]	Calculated avoidable production costs for sulfuric acid (output from GENACD in the demand subsystem, input to the manual procedure in the transportation subsystem, input to GENPGM and REPTSOL)
TRNCST[c]	Transportation costs from potential supply points to potential demand points (output from TRNCOST in the transportation subsystem, input to GENPGM)
GENDATA	Report data (output from GENPGM, input to sort procedure)
GENREPT	Same as GENDATA except sorted (output from sort procedure, input to REPTSOL)
MODLIN	Linear programing model (output from GENPGM, input to APEX)
MODLOUT	Model solution (output from APEX, input to REPTSOL)
FINRPT	On-line copy of final report (output from REPTSOL)

---

a. Described in supply subsystem file descriptions.
b. Described in demand subsystem file descriptions.
c. Described in transportation subsystem file descriptions.

TABLE IV-38. FILE FORMAT FOR POWER PLANT STRATEGY PRESELECTION RESULTS (GENDATA/GENREPT)

Field number	Description	Format
Power Plants Considered in Model Report Record		
1	Not used	10X
2	Relative sequence number of plants to be considered in the model	I4
3	SPLC	I6
4	FPC number	A10
5	Unit production costs (incremental)	F10.2
6	Production capacity to be considered in model	F10.0
7	Total heat input for capacity to be considered	F10.0
8	Plant name	3A10
9	Total disposable byproduct strategy costs	F10.0
10	Total marketable byproduct strategy costs	F10.0
Power Plant Status Report Record		
1[a]	Strategy status from preselection procedure prior to model	4A10
2	FPC number	A10
3	Emissions to be removed	F10.0

a. Possible status values: all clean fuel, all scrubbing, part clean fuel, part scrubbing, total emissions removed by clean fuel (summary), total emissions removed by scrubbing (summary).

TABLE IV-39. REPORT FORMAT FOR POWER PLANT

STRATEGY PRESELECTION RESULTS

```
      NO. SPLC   FPC CODE     COST   TONS-H2SO4   HEAT        PLANT NAME             LMSTN CSTS  MGO CSTS
        1411440 720000900     0.00     67592. 66640000.ROXBORO                         31639237. 30183021.
        23176711145001900     9.41     75726. 33788383.CAMPBELL                        16815410. 17528253.
        34957851655000300    25.23    196573. 53997072.CRYSTAL RIVER                   29567219. 31956257.
        46864632185000900     0.00    101605. 67650014.PARISH                          33537684. 32936912.
        52836252455000250    22.88    338976.127866860.GHENT                           69514691. 71695468.
       PLANT STATUS                     FPC CODE   TONS SULFUR
 ALL CLEAN FUEL                         105000100     2061.
 ALL CLEAN FUEL                         220000100     4848.
 ALL CLEAN FUEL                         410000100     7156.
 ALL CLEAN FUEL                         720000100     4667.
 ALL SCRUBBING                          720000900    22071.
 ALL SCRUBBING                         2345000200     5982.
 ALL SCRUBBING                         3945000600    19677.
 ALL SCRUBBING                         4740000100    15803.
 ALL SCRUBBING                         4785009910    12259.
 PART CLEAN FUEL                       1145001900    13786.
 PART SCRUBBING                        1145001900    24727.
 TOTAL EMISSIONS REMOVED CLEAN FUEL (TONS S)       2113473.
 TOTAL EMISSIONS REMOVED SCRUBBING  (TONS S)        385593.
 WESTERN POWER PLANT                   3705002700    731146
 WESTERN POWER PLANT                   4035000350    783120
```

TABLE IV-40. REPORT FORMAT FOR MODEL SOLUTION

```
PROBLEM NAME  $.50 ACFL

TOTAL INDUSTRY COST                                        649486.18

 TOTAL ACID TRANSPORT COST                                  12740.67
 TOTAL EASTERN SMELTER ACID PRODUCTION COST                     0.00
 TOTAL WESTERN SMELTER ACID PRODUCTIN COST                      0.00
 TOTAL CANADIAN ACID PRODUCTION COST                         3002.00
 TOTAL EASTERN STEAM PLANT PRODUCTION COST                   2337.06
 TOTAL MARKET INCENTIVE FOR STEAM PLANT ACID                    0.00
 TOTAL ACID PLANT PRODUCTION COST(PORT SULFUR)             631406.44

TOTAL ACID PLANT DEMAND (000 TONS)                            23255.
```

(continued)

TABLE IV-40 (continued)

		CAPACITY	SALES
EASTERN SMELTER SALES		419.	419.
WESTERN SMELTER SALES			
ARIZONA	CHICAGO		0.00
ARIZONA	ST.LOUIS		0.00
ARIZONA	MEMPHIS		0.00
ARIZONA	BATONROUGE		0.00
ARIZONA	HOUSTON		118.00
ARIZONA	TOTAL	118.00	118.00
NEW MEXICO	CHICAGO		50.00
NEW MEXICO	ST.LOUIS		166.00
NEW MEXICO	MEMPHIS		0.00
NEW MEXICO	BATONROUGE		50.00
NEW MEXICO	HOUSTON		9.00
NEW MEXICO	TOTAL	380.00	275.00
UTAH	CHICAGO		0.00
UTAH	ST.LOUIS		96.00
UTAH	MEMPHIS		0.00
UTAH	BATONROUGE		0.00
UTAH	HOUSTON		0.00
UTAH	TOTAL	96.00	96.00
MONTANA	CHICAGO		0.00
MONTANA	ST.LOUIS		144.00
MONTANA	MEMPHIS		0.00
MONTANA	BATONROUGE		0.00
MONTANA	HOUSTON		0.00
MONTANA	TOTAL	144.00	144.00
CANADIAN ACID SALES			
BUFFALO			200.00
DETROIT			0.00
CANADA TOTAL		200.00	200.00
EASTERN STEAM PLANT SALES		780.472	315.923
PORT SULFUR SALES			**22320.077**

(continued)

TABLE IV-40 (continued)

```
ACID PLANT PURCHASE SUMMARY

                                                                  DEMAND       COST
  1AGRICO CHEM-WILLIAMS PIERCE       FL
   PORT SULFUR PURCHASES                                            900.
                                                                 900.000      24.57
  2AGRICO CHEM-WILLIAMS DONALDSONVL  LA
   PORT SULFUR PURCHASES                                            900.
                                                                 900.000      27.18
  7ALLIED CHEMICAL CORP GEISMAR      LA
   PORT SULFUR PURCHASES                                            375.
                                                                 375.000      26.07
 10ALLIED CHEMICAL CORP NITRO        WV
   PORT SULFUR PURCHASES                                            101.
                                                                 101.000      38.83
 11ALLIED CHEMICAL CORP HOPEWELL     VA
   PORT SULFUR PURCHASES                                            150.
                                                                 150.000      36.56
 13ALLIED CHEMICAL CORP FRONT ROYAL  VA
   PORT SULFUR PURCHASES                                            120.
                                                                 120.000      35.21
 15AMERICAN CYANAMID    BOUND BROOK  NJ
   PORT SULFUR PURCHASES                                             49.
   CANADA-BUFFALO                                                  0.000      43.91
                                                                  49.000      24.79
 16AMERICAN CYANAMID    MOBILE       AL
   PORT SULFUR PURCHASES                                             20.
                                                                  20.000      36.06
 17AMERICAN CYANAMID    JOLIET       IL
   PORT SULFUR PURCHASES                                             38.
   STEAM PLANT  2 1145001900 CAMPBELL                             11.274      44.07
                                                                  26.726      30.23
 18AMERICAN CYANAMID    SAVANNAH     GA
   PORT SULFUR PURCHASES                                            162.
                                                                 162.000      29.61
```

(continued)

TABLE IV-40 (continued)

EASTERN SMELTER SALES SUMMARY

			CAPACITY	SALES	SALES PRICE
EASTERN SMELTER NEW JERSEY ZINC CO	PALMERTON	PA	26.000	26.000	
133 E I DUPONT DE NEM GIBBSTOWN	NJ			26.000	12.79
EASTERN SMELTER ST JOE MINERALS	HERCULANEUM	MO	14.000	14.000	
75 MONSANTO COMPANY E ST LOUIS	IL			14.000	11.66
EASTERN SMELTER AMER METAL (AMAX)	MONSANTO	IL	12.000	12.000	
75 MONSANTO COMPANY E ST LOUIS	IL			12.000	8.92
EASTERN SMELTER AMAX LEAD COMPANY	SALEM(BUICK)	MO	7.000	7.000	
75 MONSANTO COMPANY E ST LOUIS	IL			7.000	17.71
EASTERN SMELTER ENGELHARD-NAT*L ZINC	BARTLESVILLE	OK	9.000	9.000	
91 PENNSALT CHEMICALS TULSA	OK			9.000	8.29
EASTERN SMELTER ST JOE MINERALS	JOSEPHTOWN	PA	54.000	54.000	
72 MINN MIN + SMELT COPLEY	OH			41.000	15.96
137 ALLIED CHEMICAL CORP CLEVELAND	OH			13.000	18.36
EASTERN SMELTER CITIES SERVICE OIL	COPPERHILL	TN	200.000	200.000	
27 ARMY AMMUNITION PLT TYNER	TN			99.000	14.08
28 ARMY AMMUNITION PLT RADFORD	VA			23.000	21.58
68 KERR-MCGEE COTTONDALE	FL			11.000	23.41
95 REICHHOLD CHEMICALS TUSCALOOSA	AL			41.000	21.04
128 HOME GUANO COMPANY DOTHAN	AL			8.000	22.81
130 COLUMBIA NITROGEN MOULTRIE	GA			18.000	21.58
EASTERN SMELTER AMER SMELT(ASARCO)	EL PASO	TX	16.000	16.000	
138 EL PASO PRODUCTS EL PASO	TX			16.000	6.18

(continued)

TABLE IV-40 (continued)

CANADA SALES SUMMARY

			SALES	SALES PRICE
BUFFALO				
15	AMERICAN CYANAMID	BOUND BROOK NJ	49.000	24.79
51	E I DUPONT DE NEM	CORNWELLS HTSPA	56.000	26.03
53	ESSEX CHEMICAL CO	NEWARK NJ	12.000	23.48
133	E I DUPONT DE NEM	GIBBSTOWN NJ	57.000	29.37
135	CITIES SERVICE OIL	MONMOUTH JCT NJ	26.000	24.79
DETROIT				

(continued)

TABLE IV-40 (continued)

WESTERN SALES SUMMARY					SALES	SALES PRICE
ARIZONA						
HOUSTON	88	OLIN CORPORATION	PASADENA	TX	118.000	27.56
NEW MEXICO						
CHICAGO	17	AMERICAN CYANAMID	JOLIET	IL	50.000	25.54
ST.LOUIS	79	NL INDUSTRIES INC	ST LOUIS	MO	166.000	28.16
BATONROUGE	126	AMERICAN CYANAMID	FORTIER	LA	50.000	29.56
HOUSTON	88	OLIN CORPORATION	PASADENA	TX	9.000	27.56
UTAH						
ST.LOUIS	75	MONSANTO COMPANY	E ST LOUIS	IL	96.000	27.000
MONTANA						
ST.LOUIS	79	NL INDUSTRIES INC	ST LOUIS	MO	144.000	28.79

(continued)

TABLE IV-40 (continued)

STEAM PLANT SALES SUMMARY

				CAPACITY	INCREMENTAL COST	SALES	SALES PRICE
1	720000900 ROXBORO			67.592	0.000		
98	ROYSTER COMPANY	NORFOLK	VA			15.00	17.110
108	SWIFT CHEM CO	WILMINGTON	NC			.59	17.110
109	SWIFT CHEM CO	NORFOLK	VA			26.00	17.110
119	WEAVER FERTILIZER	NORFOLK	VA			26.00	17.110
2	1145001900 CAMPBELL			75.726	9.410		
17	AMERICAN CYANAMID	JOLIET	IL			26.73	30.230
19	AMERICAN CYANAMID	KALAMAZOO	MI			19.00	17.490
107	SWIFT CHEM CO	CALUMET CITY	IL			30.00	30.230
3	1655000300 CRYSTAL RIVER			196.573	25.230		
4	2185000900 PARISH			101.605	0.000		
88	OLIN CORPORATION	PASADENA	TX			101.61	6.180
5	2455000250 GHENT			338.976	22.880		
20	AMERICAN CYANAMID	HAMILTON	OH			71.00	34.030

(continued)

Linear Programing Model Problem File (MODLIN)

The MODLIN file contains the marketing model in the format required by the APEX linear programing system, and is generated by the GENPGM program. Users requiring exact details should refer to a source program listing of the GENPGM program and an APEX users manual (see Appendix B). A detailed understanding of the file format is not necessary to use the system.

Linear Programing Model Solution File (MODLOUT)

The MODLOUT file is produced by the APEX linear programing system. It contains the solution to the model and allows customized reports to be developed in addition to the standard APEX reports. The file is used in the REPTSOL program to generate a final report analysis of the strategy selection process, including the model solution. Users requiring exact details should refer to a source program listing of the REPTSOL program and an APEX users manual (see Appendix B). A detailed understanding of the file format is not necessary to use the system.

V. SYSTEM USAGE

GENERAL

The byproduct marketing system was developed on the Control Data Corporation (CDC) CYBERNET system which provides both interactive (conversational) time-sharing services and remote batch processing by means of a nationwide commercial data processing network. A list of manuals related to the use of the byproduct marketing system on the CYBERNET system is provided in Appendix B. The Interactive Service Reference Set, Volume 1, Tutorial, provides comprehensive descriptions and illustrations (including logging into the system, user input, and terminal responses) of the procedures and examples shown in this section.

Initially the system will not be kept on-line for independent, full-time, interactive-batch access by all users. Many potential users may not have a contractual agreement with CDC to access the CYBERNET system. Even where agreements do exist, the background experience required to fully utilize the capabilities of the byproduct marketing system itself as well as the capabilities related to its use on CYBERNET may be unavailable or too costly to develop during a preliminary investigation of potential benefits. Another consideration is the actual cost of keeping the system on-line full time. The storage charges that would be incurred, especially during the initial stages of system availability, would probably be excessive when compared to the level of usage.

Under an information exchange agreement between EPA and TVA, capabilities will be provided by TVA to process user requests (subject to limitations based upon available funding, the costs that would have to be absorbed, and the source of and justification for the requests). This will allow users to analyze some of the general system capabilities with a minimum amount of investigation and investment. After analyzing the results obtained and the associated costs that were incurred to provide the results (approximate costs that had to be absorbed to satisfy a given request will be included with the results) each user should be able to determine if potential benefits justify independent usage and billing. This will also allow a more cost-effective use of the funds for information exchange since several user requests can probably be processed together to reduce both the man-hours and computer resources required.

The system will be kept on-line for independent full-time access by all users only when this is justified by level of usage, the availability of funding, and the number of users with the requirements and capability to use the system independently.

Even when the system is available on a full-time on-line basis, users desiring to access the system independently must have the necessary contractual agreement for direct billing by CDC since neither TVA nor EPA can be responsible for computer charges that are not directly under their control. (This would not necessarily apply to the storage charges for keeping the system on-line for all users.)

It is the intent of the information exchange agreement between EPA and TVA to give potential users the opportunity to investigate possible benefits from the byproduct marketing system. The capability provided by TVA under the information exchange agreement may be simply providing clarification and additional information about the system as well as providing computer runs. In either case when the requirements of a specific user affect the service that can be provided to all users, the user will be required to establish procedures for independent access and direct billing.

For those users who require complete freedom to access and modify the system to their own specifications, special arrangements can probably be made to provide individual copies of the system by means of magnetic tape or by copying the system from on-line files, either into the users' own catalog of files or onto off-line storage facilities. These users would then have total freedom of use of the system but would have to obtain updated versions of the system as they become available and would be responsible for charges associated with their individual copies of the data and programs.

Those users whose requirements can be satisfied as a result of the information exchange agreement will find the remainder of the sections on actual usage unnecessary except as an aid to further understanding of the internal relationships between the various parts of the system. Other users, who prefer to access the system independently, should analyze the remainder of the sections on usage very carefully; they will have an effect on both the results and the cost of obtaining the results.

EXECUTION MODES

The CDC CYBERNET system provides distinctly different operating environments that may be used for processing such applications as the byproduct marketing system. If interactive time-sharing capabilities are unnecessary and remote job entry (RJE) facilities are available, the SCOPE 3.4 BATCH SERVICE and CYBER 76 BATCH SERVICE offer priority schedules that may result in significant savings. If interactive time-sharing is required, the NOS INTERACTIVE AND BATCH SERVICE is the logical choice. In addition to interactive time-sharing, NOS also provides two optional types of batch capabilities. The first batch option is a standard RJE capability with the only difference from the SCOPE 3.4 and CYBER 76 services being that NOS assigns time-sharing tasks a higher priority than remote batch tasks. The second NOS batch option allows interactive users to mix either single batch commands or groups of batch commands with normal conversational commands and execute both types during a single time-sharing session. It also allows interactive users to create a complete batch run at the terminal and submit it to the system to be executed completely independent of the time-sharing session in the same way that a card deck would be prepared and submitted to the system through an RJE terminal. Significantly reduced costs may be realized by the use of NOS deferred batch processing which is the same as standard RJE batch except that runs are deferred until after normal working hours and lower rates apply. In order to take advantage of the specific capabilities of each of the operating environments, users of either interactive or remote batch terminals can transmit jobs to any of the three systems through the CYBERLINK Communications Interchange.

Because NOS provides capabilities for both interactive time-sharing and remote batch processing as well as some combined capabilities of both, it was selected as the primary system for the byproduct marketing programs and data bases. While some of the tasks required for previous models were not processed on NOS (because of core requirements, storage requirements, or processing time requirements) the added complexity that would result for users from splitting the data bases, files, and programs over more than one operating system is not justified on a potential cost-saving basis. It is not possible to provide enough information here to allow users to take advantage of all the CYBERNET network capabilities and the usage sections, including examples, will be limited to NOS. Users with the expertise to utilize the other operating systems should have no problem adapting to the operating system or combination of systems that will best meet their own requirements.

The text editor should provide the necessary capability for examination and modification of the independently provided files, as well as the intermediate files generated within the system. The only exceptions are the power plant System 2000 data base and the binary files, but modifications to these are not necessary during normal use of the system. The text editor will also allow examination and modification of the procedure files and source programs where necessary without any compilations or program executions required.

The mode of execution of the various programs is a function of the system resources that will be required and their associated costs. All of the programs can be executed in either interactive, batch, or combined interactive-batch mode but in most cases the individual program characteristics make one mode of execution preferable to another.

For the ADDLIME, ACDUPDT, GENACD, GENPGM, and REPTSOL programs and the transportation manual procedure with its text editing requirements, execution during a time-sharing session offers the greatest amount of flexibility without significantly increasing costs. The scrubbing cost generator can also be executed in a time-sharing session if the execution is on a stand-alone basis with user-supplied power plant data.

The PROJECT, TRNCOST, and APEX programs, as well as the scrubbing cost generator program when executed as a part of the supply subsystem using the power plant data from the data base (after appropriate processing by the PROJECT program) are more economically executed in a deferred batch mode. The batch run may be created in a time-sharing mode and submitted independently of the time-sharing session or it may be submitted through an RJE terminal, but in general these programs are not executed interactively on a routine basis.

The above guidelines for program execution will obviously depend on individual requirements; there will be exceptions, such as a very small model, a large quantity of user-supplied data to the scrubbing cost generator program, etc., but users should make certain that they understand all of the potential cost implications before deviating from the suggested modes of execution. Those users accessing the system independently should be careful if they choose to directly access or modify the System 2000 data base. As mentioned previously there is a potential for significant charges to be incurred.

In most of the usage examples (both batch and interactive) the programs are executed from relocatable program modules generated during previous program compilations. This saves the resources required to recompile each time the program is executed.

Before beginning any system usage, verification that the necessary files are present can be made using the CATLIST command. An example is shown in Table V-1. Note that the System 2000 power plant data base consists of six different files instead of a single file. These six files have "TA" through "TF" as the first two characters of the file name; the last five characters are a hash code derived from the data base name. The CATLIST command should also be used during the various stages of system execution to verify that the appropriate files have been created and catalogued.

Time-Sharing Execution

The text editor is the most convenient method for the examination and modification of the data files, programs, and procedure files used in the system. Individual fields or entire files may be edited, complete records may be added or deleted, and new files may be created using the text editor. Most users should find it helpful to examine some of the actual data and program files (referring as necessary to section IV on file and record descriptions and section III on program documentation) before attempting any program executions. It is expected that the text editor will also be used to create or modify any batch runs that will be executed independently of a time-sharing session.

The first program typically executed in a time-sharing session is the ADDLIME program. This program takes the plant data file from the

TABLE V-1. SAMPLE LISTING OF THE PERMANENT FILE CATALOG TO VERIFY THAT THE NECESSARY FILES ARE PRESENT FOR SYSTEM USAGE AND A SAMPLE LISTING OF THE CATALOG AFTER ALL PROGRAMS HAVE BEEN EXECUTED

```
/CATLIST
 CATALOG OF USERNUM                          78/06/01. 15.14.27

  FILE NAMES(S)

  TA2SHUO   TB2SHUO   TC2SHUO   TD2SHUO   TE2SHUO   TF2SHUO   PROJECT
  PRJLGO    ADDLIME   LIMEEST   STMCAP    SCRLGO    BSCROPT   ISCROPT
  SASDAT6   SCRPRC    SCRSIT    ACDUPDT   RAILWA    SACDSML   SULTER
  X313SUL   GENACD    GENALGO   ACDPAR    RBNSORT   TRNPTS    X313H2S
  TRNCOST   TRNLGO    GENPGM    GENPLGO   REPTSOL   RPGLGO    RAILCAL
  BYP       BPRJ      BSCR      BTRN      BLPRPG

      40  FILE(S)
```

```
/CATLIST
 CATALOG OF USERNUM                          78/06/08. 12.15.02

  FILE NAME(S)

  TA2SHUO   TB2SHUO   TC2SHUO   TD2SHUO   TE2SHUO   TF2SHUO   PROJECT
  PRJLGO    ADDLIME   LIMEEST   STMCAP    SCRLGO    BSCROPT   ISCROPT
  SASDAT6   SCRPRC    SCRSIT    ACDUPDT   RAILWA    SACDSML   SULTER
  X313SUL   GENACD    GENALGO   ACDPAR    RBNSORT   TRNPTS    X313H2S
  TRNCOST   TRNLGO    GENPGM    GENPLGO   REPTSOL   RPGLGO    RAILCAL
  BYP       BPRJ      BSCR      BTRN      BLPRPG    PLAS      BLAS
  PRJOUT    UPLIME    ADLOUT    SCRCST    SCROUT    SCRDAY    SCR20
  SCR30     SCR40     ACDUOUT   ACDSML    ACDRPT    ACDCST    SMLCST
  TRNCST    TRNOUT    TRNDAY    GENDATA   GENREPT   MODLIN    APXRPT
  MODLOUT   FINRPT    BYPDAY

      66  FILE(S)
```

PROJECT program and adds the delivered cost of limestone to each power plant record (based on the FPC number) from the independent LIMEEST file. The UPLIME file is output from the program. This program execution is necessary only if new plant and boiler data files are created by execution of the PROJECT program (see section III). Sample usage of the program in a time-sharing session is shown in Tables V-2 and V-3.

The second program typically executed in a time-sharing session is the stand-alone application of the scrubbing cost generator to make calculations based on user-supplied power plant, boiler, and regulation data. As shown in the program description in section III, the investment and operating factors file (SASDAT6); the cost data (SCRPRC); and the file of options, overrides, plant data, and boiler data are required for program execution. The output is dependent on the options and overrides used. Sample usage of the program in a time-sharing session is shown in Tables V-4 and V-5. Table V-6 shows a sample input file for interactive use containing options, overrides, and user data.

The ACDUPDT program is typically executed in a time-sharing session. As shown in section III, the sulfur tariff data file (X313SUL), the rail mileage file (RAILWA), the acid plant and smelter file (SACDSML), and the sulfur terminal file (SULTER) are required. Output is a report of delivered sulfur costs and an acid plant and smelter file (ACDSML) containing delivered costs of sulfur. Sample program usage is shown in Tables V-7 and V-8.

The GENACD program is typically executed in a time-sharing session. The data for avoidable production cost generation (ACDPAR), the acid plant and smelter file with updated costs (ACDSML), the file names to be used, and the report selection options are required during execution. Output is an acid cost file, a smelter cost file, and selected reports. Sample program usage is shown in Tables V-9 and V-10.

The transportation manual procedure to provide transportation locations and the associated data in the TRNPTS file is typically done in a time-sharing session using the text editor. The output file from the scrubbing cost generator (SCRCST), the output files from the avoidable production cost generator (ACDCST and SMLCST), the transshipment terminal data in GENPGM and the external file of rail rate basing point data (RBNSORT) must be referred to for the data. As new power plants, acid plants, smelters, sulfur terminals, or transshipment terminals are considered, the appropriate records must be added to the TRNPTS file in correct sequence by means of the text editor. A sample time-sharing session to add a power plant location-related record to the TRNPTS file is shown in Table V-11.

GENPGM, the first program in the linear programing model subsystem, is typically executed in a time-sharing session even though the subsequent solution of the model by the APEX program is done in batch mode. The output files from the other subsystems must be provided as input, and user options, including the ACFL, must be provided during program execution. Once the model is created the only remaining option is to either

TABLE V-2. SAMPLE PROCEDURE FILE TO INTERACTIVELY EXECUTE THE PROGRAM THAT ADDS DELIVERED LIMESTONE COSTS (ADDLIME)

```
  .
  .
01740 1ADDLIM,OLD,MESSAGE/UN=LIBRARY.
01760 MESSAGE.  EXECUTE ADD LIMESTONE COSTS (ADDLIME)
01780 GET,ADDLIME.
01800 GET,TAPE1=BFLAS.
01820 GET,TAPE2=LIMEEST.
01840 PURGE,IADLOUT/NA.
01860 DEFINE,IADLOUT.
01880 FTN(I=ADDLIME,L=0)
01900 LGO,,IADLOUT.
01920 REPLACE,TAPE3=IUPLIME.
01940 RETURN,ADDLIME,LGO,TAPE1,TAPE2.
01960 MESSAGE.  ADD LIME COMPLETE.
01980 RETURN,MESSAGE.
02000 GOTO,9END.
02020 EXIT.
02040 MESSAGE.  ADD LIME FAILED, DAYFILE TO FOLLOW.
02060 RETURN,MESSAGE.
02080 GOTO 9EXIT.
  .
  .
  .
```

TABLE V-3. SAMPLE USAGE OF A PROCEDURE FILE TO INTERACTIVELY EXECUTE THE ADDLIME PROGRAM

```
/OLD,PROCFIL
/-PROCFIL,S=1ADDLIM.
 10.24.30.MESSAGE.  EXECUTE ADD LIMESTONE COSTS (ADDLIME)
 10.24.37.MESSAGE.  ADD LIME COMPLETE.
9END,EXIT.
```

TABLE V-4. SAMPLE PROCEDURE FILE TO INTERACTIVELY EXECUTE THE SCRUBBING COST GENERATOR PROGRAM (STMCAP)

```
  .
  .
  .
02100 1ISCR,OLD,MESSAGE/UN=LIBRARY.
02120 MESSAGE.  EXECUTE SCRUBBING COST GENERATOR (STMCAP)
02140 GET,TAPE1=SASDAT6.
02160 GET,TAPE4=SCRPRC.
02180 RETURN,TAPE2,TAPE3.
02200 GET,SCRLGO.
02220 GET,INPUT=ISCROPT.
02222 PURGE,ISCROUT/NA.
02224 RETURN,ISCROUT.
02226 DEFINE,ISCROUT.
02240 SCRLGO,,ISCROUT.
02260 RETURN,TAPE2,TAPE3,INPUT.
02280 IF(FILE(TAPE10,AS))REPLACE,TAPE10=ISCRCST.
02300 IF(FILE(TAPE20,AS))GOTO,1T20.
02320 1T30A,IF(FILE(TAPE30,AS))GOTO,1T30.
02340 1T40A,IF(FILE(TAPE40,AS))GOTO,1T40.
02360 1T50A,MESSAGE.    SCRUBBING COST GENERATION COMPLETE.
02380 RETURN,MESSAGE.
02400 GOTO,9END.
02420 EXIT.
02440 MESSAGE.  SCRUBBING COST GENERATION FAILED
02460 MESSAGE.   DAYFILE TO FOLLOW
02480 RETURN,MESSAGE.
02500 GOTO,9EXIT.
02520 1T20,MESSAGE.  TAPE20 CREATED AND SAVED AS ISCR20.
02540 PURGE,ISCR20/NA.
02560 DEFINE,ISCR20.
02580 REWIND,TAPE20.
02600 COPY,TAPE20,ISCR20.
02620 RETURN,TAPE20,ISCR20.
02640 GOTO,1T30A.
02660 1T30,MESSAGE.  TAPE30 CREATED AND SAVED AS ISCR30.
02680 PURGE,ISCR30/NA.
02700 REWIND,TAPE30.
02720 DEFINE,ISCR30.
02740 COPY,TAPE30,ISCR30.
02760 RETURN,TAPE30,ISCR30.
02780 GOTO,1T40A.
02800 1T40,MESSAGE.  TAPE40 CREATED AND SAVED AS ISCR40.
02820 PURGE,ISCR40/NA.
02840 DEFINE,ISCR40.
02860 REWIND,TAPE40.
02880 COPY,TAPE40,ISCR40.
02900 RETURN,TAPE40,ISCR40.
02920 GOTO,1T50A.
  .
  .
  .
```

TABLE V-5. SAMPLE USAGE OF A PROCEDURE FILE TO INTERACTIVELY EXECUTE THE STMCAP PROGRAM

```
/-PROCFIL,S=1ISCR.
 12.43.17.MESSAGE.  EXECUTE SCRUBBING COST GENERATOR (STMCAP)
 12.43.32.MESSAGE.  TAPE20 CREATED AND SAVED AS ISCR20.
 12.43.35.MESSAGE.  TAPE30 CREATED AND SAVED AS ISCR30.
 12.43.40.MESSAGE.  TAPE40 CREATED AND SAVED AS ISCR40.
 12.43.43.MESSAGE.  SCRUBBING COST GENERATION COMPLETE.
9END,EXIT.
```

TABLE V-6. SAMPLE SCRUBBING COST GENERATOR (STMCAP) INPUT OPTIONS, OVERRIDES, AND USER DATA FOR INTERACTIVE EXECUTION

```
 $OPTIONS KSAS=5,LSAS=0,KPRICE=5,KOFF=0,KSIM=1,IN=5,IO=40,
  KSCAN=30,KEMISS=30,KCOSTLP=20,KCOSTP=6,LCP=0,KCHECK=1,
  KEDIT=0$
 $OVERIDE OPYEAR=1978.,PREMIS=1.2,1.2,1.3,1.2,1.2,1.2,
  CEINDX=214.7,GRACE=.1$
 $PRICIN PRICE(2)=.1E+02$
 $SASIN IU=6,ISEQU=10,JU=1,LU=1,KU=1,AU=419000.,A1U=.650,A2U=0.$
 $SASIN IU=44,ISEQU=0,JU=0,KU=0,LU=0$
 $PLANTIN IFFC=9990009910,BTUCOL=10535.8,BTUOIL=137588.5,BTUGAS=1000.,
  SULCOL=.037,SULOIL=.002,HTRATE=9860.0128537,ISPLC=436270,
  ISIP1=2,
  PEDCO=0.0,VLIME=442.,SITEFAC=1.0,1.0,1.0,1.0,1.0,1.0$
SAMPLE PLANT A
 $BLRIN IFFCB=9990009910,TOTCOLI=3089.27324,TOTOILI=0.0,TOTGASI=0.0,
  AIRI=2234600.,STRTYRI=1972,CAPFPC=.5797,GENCAP=1300.0,IB=1,
  ISIP2=07,REGC=500.0,REGO=4.00,RETRO=1.14,IPROC=1$
 $BLRIN IFFCB=9990009910,TOTCOLI=3010.732455,TOTOILI=0.0,TOTGASI=0.0,
  AIRI=2234600.,STRTYRI=1973,CAPFPC=.565,GENCAP=1300.,IB=2,
  ISIP2=03,REGC=4.0,REGO=4.0,RETRO=1.14,IPROC=4$
 $BLRIN IFFCB=00000$
```

TABLE V-7. SAMPLE PROCEDURE FILE TO INTERACTIVELY EXECUTE THE PROGRAM THAT CALCULATES DELIVERED MOLTEN SULFUR COSTS TO ALL SULFURIC ACID PLANTS (ACDUPDT)

```
  .
03340 1IACDUP,OLD,MESSAGE/UN=LIBRARY.
03360 MESSAGE.  EXECUTING ACID UPDATE PROGRAM
03380 GET,ACDUPDT.
03400 PURGE,ACDUOUT/NA.
03420 DEFINE,ACDUOUT.
03440 FTN(I=ACDUPDT,L=0)
03460 LGO,,ACDUOUT.
03480 REPLACE,TAPE8=IACDSML.
03500 RETURN,LGO,ACDUPDT.
03520 MESSAGE.  ACID UPDATE COMPLETE.
03540 RETURN,MESSAGE.
03560 GOTO,9END.
03580 EXIT.
03600 MESSAGE.  ACID UPDATE FAILED.
03620 MESSAGE. DAYFILE TO FOLLOW.
03640 RETURN,MESSAGE.
03660 GOTO,9EXIT.
  .
  .
  .
```

TABLE V-3. SAMPLE USAGE OF A PROCEDURE FILE TO INTERACTIVELY EXECUTE THE ACDUPDT PROGRAM

```
OLD,PROCFIL
READY
-PROCFIL,S=1IACDUP.
 15.55.49.MESSAGE.  EXECUTING ACID UPDATE PROGRAM
 16.00.10.MESSAGE.  ACID UPDATE COMPLETE.
9END,EXIT.
```

TABLE V-9. SAMPLE PROCEDURE FILE TO INTERACTIVELY EXECUTE THE PROGRAM THAT CALCULATES SULFURIC ACID AVOIDABLE PRODUCTION COSTS (GENACD)

```
  .
  .
  .
03680 1IACD,OLD,MESSAGE/UN=LIBRARY.
03700 MESSAGE.  EXECUTE ACID PRODUCTION COST( GENACD)
03720 PURGE,IACDRPT/NA.
03740 PURGE,IACDCST/NA.
03760 PURGE,ISMLCST/NA.
03780 GET,GENALGO.
03800 GENALGO.
03820 RETURN,GENALGO.
03840 SAVE,TAPE7=ISMLCST.
03860 SAVE,TAPE4=IACDCST.
03880 SAVE,TAPE3=IACDRPT.
03900 MESSAGE.  ACID PRODUCTION COST COMPLETE
03920 MESSAGE.  REPORT FILE IS IACDRPT.
03940 RETURN,MESSAGE.
03960 GOTO,9END.
03980 EXIT.
04000 MESSAGE.  ACID COST FAILED, DAYFILE TO FOLLOW.
04020 RETURN,MESSAGE.
04040 GOTO,9EXIT.
  .
  .
  .
```

TABLE V-10. SAMPLE USAGE OF A PROCEDURE FILE TO INTERACTIVELY EXECUTE THE GENACD PROGRAM

```
/OLD,PROCFIL
/-PROCFIL,S=1IACD.
 14.13.19.MESSAGE.  EXECUTE ACID PRODUCTION COST( GENACD)
 ENTER ACID PARAMETER FILE NAME
? SACDPAR
 ENTER ACID PLANT FILE NAME
? SACDSML
 ENTER EASTERN(1) OR WESTERN(2) REGION CODE
? 1


 IS SPECIAL REPORT DESIRED (YES OR NO)
? YES
ENTER SPECIAL REPORT #(1,3 OR 8,9=ALL,0=REPORT NAMES)
? 9
 14.16.06.MESSAGE.  ACID PRODUCTION COST COMPLETE
 14.16.17.MESSAGE.  REPORT FILE IS IACDRPT.
9END,EXIT.
```

TABLE V-11. SAMPLE TERMINAL SESSION TO ADD A POWER PLANT

TO THE TRANSPORTATION FILE (TRNPTS)

```
 OLD,TRNPTS
/XEDIT
 XEDIT 3.0.6
?? N90
000
?? F 10
000
10400002003422120    341800155502
10400003003414740          153202
14000006002181110    218364146102
17900025504569400    456940240701
17900028004538970    455370240601
35450007003472150          153602
38000008002041380    204210151102
45100001004729440    472872260801
47400003004977950    498464251601
?? N -7
10400003003414740          153202
?? I 1
? 13950002504131830    413183203901
?? F 5
13950002504131830    413183203901
14000006002181110    218364146102
17900025504569400    456940240701
17900028004538970    455370240601
35450007003472150          153602
?? Q,,RL
TRNPTS REPLACED
TRNPTS IS A LOCAL FILE
AEB ,      0.428UNTS.
```

solve it or discard it; no capability is provided for modifications after it has been built. In addition to the model a data file to be used in a final report is also created and must be sorted if the model is to be solved and a report prepared of the results. The GENSORT procedure to do this uses the ZORT control statement and is included in the procedure for program GENPGM. Sample usage of program GENPGM and the GENSORT procedure (ZORT) are shown in Tables V-12 and V-13.

Batch Execution

"Batch" as used in this section refers to the execution of an independent run stream just as though it was submitted through an RJE terminal. This same type of run can also be created and submitted during a time-sharing session but it is executed completely independently of the time-sharing session once it has been submitted to the system.

The use of the word batch in the above context should not be confused with the CYBERNET NOS definition in connection with the execution of batch commands during a time-sharing session. Usage of the batch subsystem during a time-sharing session to execute one or more batch commands, as opposed to submitting a batch run to be executed independently of the time-sharing session, is a CYBERNET NOS option not related to a typical RJE batch run.

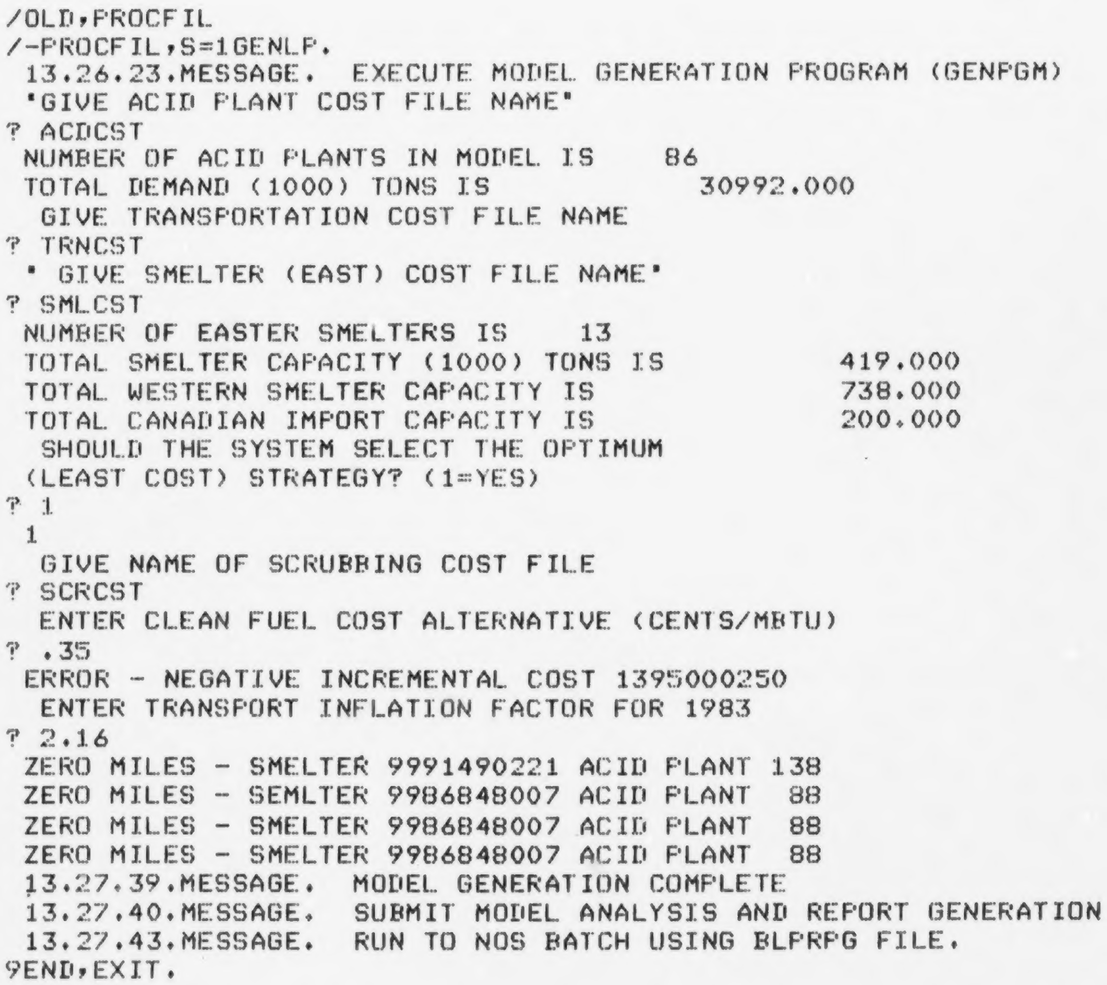
In the batch execution examples that will be shown, the runs were generated specifically for this manual and were limited for cost purposes. Because of their simplicity they were submitted as normal batch (priority P4) rather than deferred batch (priority P2). This results in a single interactive terminal session where a run is submitted; the status is checked to verify that the run is in the input queue; the status is checked again after a short time within the same terminal session; the run is found to have executed; and the DAYFILE is checked for correct execution. Use of normal batch does not offer the cost reductions of deferred batch. For actual system runs, batch jobs (runs) will normally be submitted as deferred batch in a terminal session on any given day, the job will be run overnight, and a status check and verification of results will be made on the following day. This specific situation will be shown in the figures related to the use of the APEX package to solve the model and the generation of a report of the solution.

The PROJECT program is the first program in the supply subsystem and is typically executed in batch mode. A run stream to execute the program is prepared in a time-sharing session and submitted to the system. The power plant data base is required to execute the program. The output from the batch run can be saved for examination in a later time-sharing session, it can be printed at an RJE site, or it can be printed onsite and sent to the user. All examples shown save the results for later examination in a time-sharing session when final disposition can be determined. A sample job stream to execute the power plant projection program in batch mode is shown in Table V-14.

TABLE V-12. SAMPLE PROCEDURE FILE TO INTERACTIVELY EXECUTE THE PROGRAM THAT BUILDS THE LINEAR PROGRAMING MARKETING MODEL (GENPGM)

```
   .
   .
   .
04060 1IGENLP,OLD,MESSAGE/UN=LIBRARY.
04080 MESSAGE.  EXECUTE  MODEL GENERATION PROGRAM (GENPGM)
04100 PURGE,MODLIN/NA.
04120 DEFINE,TAPE4=MODLIN.
04140 GET,GENPLGO.
04160 GENPLGO.
04180 RETURN,GENPLGO.
04200 4CONT,REWIND,TAPE8.
04220 RENAME,GENDATA=TAPE8.
04240 RFL,50000.
04260 ZORT(GENDATA,TAPE8,110,Z,A,C,1,10)
04280 PURGE,GENREPT/NA.
04300 SAVE,TAPE8=GENREPT.
04320 RETURN,TAPEX.
04340 MESSAGE.  MODEL GENERATION COMPLETE
04360 MESSAGE.  SUBMIT MODEL ANALYSIS AND REPORT GENERATION
04380 MESSAGE.  RUN TO NOS BATCH USING BLPRPG FILE.
04400 RETURN,MESSAGE.
04420 GOTO,9END.
04440 EXIT.
04460 4EXIT,MESSAGE.  (GENPGM) FAILED TO EXECUTE.
04480 MESSAGE. DAYFILE TO FOLLOW
04500 RETURN,MESSAGE.
04520 GOTO,9EXIT.
   .
   .
   .
```

TABLE V-13. SAMPLE USAGE OF A PROCEDURE FILE TO INTERACTIVELY EXECUTE THE GENPGM PROGRAM



```
/OLD,PROCFIL
/-PROCFIL,S=1GENLP.
 13.26.23.MESSAGE.  EXECUTE MODEL GENERATION PROGRAM (GENPGM)
 'GIVE ACID PLANT COST FILE NAME'
? ACDCST
 NUMBER OF ACID PLANTS IN MODEL IS    86
 TOTAL DEMAND (1000) TONS IS            30992.000
  GIVE TRANSPORTATION COST FILE NAME
? TRNCST
 ' GIVE SMELTER (EAST) COST FILE NAME'
? SMLCST
 NUMBER OF EASTER SMELTERS IS    13
 TOTAL SMELTER CAPACITY (1000) TONS IS          419.000
 TOTAL WESTERN SMELTER CAPACITY IS              738.000
 TOTAL CANADIAN IMPORT CAPACITY IS              200.000
  SHOULD THE SYSTEM SELECT THE OPTIMUM
 (LEAST COST) STRATEGY? (1=YES)
? 1
 1
  GIVE NAME OF SCRUBBING COST FILE
? SCRCST
  ENTER CLEAN FUEL COST ALTERNATIVE (CENTS/MBTU)
? .35
 ERROR - NEGATIVE INCREMENTAL COST 1395000250
  ENTER TRANSPORT INFLATION FACTOR FOR 1983
? 2.16
 ZERO MILES - SMELTER 9991490221 ACID PLANT 138
 ZERO MILES - SEMLTER 9986848007 ACID PLANT  88
 ZERO MILES - SMELTER 9986848007 ACID PLANT  88
 ZERO MILES - SMELTER 9986848007 ACID PLANT  88
 13.27.39.MESSAGE.  MODEL GENERATION COMPLETE
 13.27.40.MESSAGE.  SUBMIT MODEL ANALYSIS AND REPORT GENERATION
 13.27.43.MESSAGE.  RUN TO NOS BATCH USING BLPRPG FILE.
9END,EXIT.
```

TABLE V-14. SAMPLE JOB STREAM TO EXECUTE THE POWER PLANT PROJECTION PROGRAM IN BATCH MODE (PROJECT)

```
00100 /JOB
00110 JOB,P4,T1000.
00120 ACCOUNT,USERNUM,PASSWOR,KC.
00130 CHARGE,CHARGNO,*SFX*PROJECTNO.
00140 PURGE,BBLAS/NA.
00150 GET,PRJLGO.
00160 SBULIM(JS=500)
00170 PRJLGO.
00180 REPLACE,TAPE9=BPLAS.
00190 REWIND,TAPE10.
00200 DEFINE,BBLAS.
00210 COPY,TAPE10,BBLAS.
00220 PURGE,BPRJOUT/NA.
00230 DEFINE,BPRJOUT.
00235 ENQUIRE,R.
00240 REWIND,OUTPUT.
00250 COPY,OUTPUT,BPRJOUT.
00260 PURGE,BPRJDAY/NA.
00265 DEFINE,BPRJDAY.
00270 DAYFILE,BPRJDAY.
00280 EXIT.
00290 PURGE,BPRJOUT/NA.
00300 DEFINE,BPRJOUT.
00305 ENQUIRE,R.
00310 REWIND,OUTPUT.
00320 COPY,OUTPUT,BPRJOUT.
00330 PURGE,BPRJDAY/NA.
00340 DEFINE,BPRJDAY.
00350 DAYFILE,BPRJDAY.
00360 /EOR
00370 ALL
00500 /EOF
```

A sample run submitted using a procedure file, checking the job status after submittal, and checking of results after execution is complete is shown in Table V-15.

The scrubbing cost generator program (STMCAP), when executed as a part of the supply subsystem using the files created by the PROJECT and ADDLIME programs, is typically executed in batch mode as shown in Tables V-16 and V-17. Based on the program description in section III, the file of investment and operating factors (SASDAT6), the file of cost data (SCRPRC), the plant-level data file with delivered costs of limestone (UPLIME), the boiler-level data file (BLAS), a file of site-specific adjustment factors (SCRSIT, optional), and the options and overrides to be used are required for program execution. (If the ADDLIME program is not executed, a default delivered cost of limestone is assumed equally for all plants and the PLAS file can be used.) The batch run is typically submitted during a time-sharing session and, depending on the volume, the output is either saved for examination in a later time-sharing session or is printed at an RJE site.

The TRNCOST program is also typically executed in batch mode. The TRNPTS file from the manual transportation procedure, the rail mileage file (RAILWA), and the sulfuric acid tariff table file (X313H2S) are required. An output report and a transportation cost file are created during program execution. Sample usage is shown in Tables V-18 and V-19.

The linear programing marketing model is typically solved by APEX and a report of the solution is generated by the GENPGM program in batch mode. The report generation step could be done in a time-sharing session from a cost basis, but because the model is solved in batch mode and a report is almost always required, there is no point in separating the two functions. The run is generated in a time-sharing session and submitted to the system to be executed in deferred batch mode. Sample usage is shown in Tables V-20 through V-22.

TABLE V-15. EXAMPLE OF SUBMITTING A BATCH RUN TO EXECUTE THE PROJECT PROGRAM;

CHECKING THE JOB STATUS; AND CHECKING FOR CORRECT EXECUTION

```
 OLD,BPROJ
/SUBMIT,BPROJ,N.
 18.56.58.ASIOBNA
/ENQUIRE,JN=BNA.
  ASIOBNA IN INPUT QUEUE.

   .
   .
   .

/ENQUIRE,JN=BNA.
 ASIOBNA NOT FOUND.
/ATTACH,BPRJDAY.
/LNH,FN=BPRJDAY.
 18.59.58.JOB,P4,T1000.
 18.59.58.ACCOUNT,USERNUM,,KC.
 18.59.58.ABG , P4.
 18.59.59.CHARGE,CHARG**,*SFX*PROJNO.
 18.59.59.PURGE,BBLAS/NA.
 19.00.00.GET,PRJLGO.
 19.00.00.SBULIM(JS=500)
 19.00.03.PRJLGO.
 19.00.49.ABD , SY04     .
 19.08.32.     STOP  PRJEND
 19.08.32.AEB ,     284.132UNTS.
 19.08.32.REPLACE,TAPE9=BPLAS.
 19.08.33.REWIND,TAPE10.
 19.08.33.DEFINE,BBLAS.
 19.08.33.COPY,TAPE10,BBLAS.
 19.08.34. END OF INFORMATION ENCOUNTERED.
 19.08.34.PURGE,BPRJOUT/NA.
 19.08.34.DEFINE,BPRJOUT.
 19.08.34.ENQUIRE,R.
 19.08.34. ENQUIRY COMPLETE.
 19.08.35.REWIND,OUTPUT.
 19.08.35.COPY,OUTPUT,BPRJOUT.
 19.08.35. END OF INFORMATION ENCOUNTERED.
 19.08.35.PURGE,BPRJDAY/NA.
 19.08.35.DEFINE,BPRJDAY.
 19.08.35.DAYFILE,BPRJDAY.
```

TABLE V-16. SAMPLE JOB STREAM TO EXECUTE THE SCRUBBING COST GENERATOR PROGRAM IN BATCH MODE (STMCAP)

```
00100 /JOB
00110 JOB,P4,T3000.
00120 ACCOUNT,USERNUM,PASSWOR,KC.
00130 CHARGE,CHARGNO,*SFX*PROJECTNO.
00140 PURGE,BSCR20/NA.
00150 PURGE,BSCR30/NA.
00160 PURGE,BSCR40/NA.
00165 PURGE,BSCRCST/NA.
00170 DEFINE,BSCR20.
00180 DEFINE,BSCR30.
00190 DEFINE,BSCR40.
00200 GET,INPUT=BSCROPT.
00210 GET,TAPE1=SASDAT6.
00220 GET,TAPE4=SCRPRC.
00230 GET,SCRLGO.
00240 GET,TAPE8=IUPLIME.
00250 ATTACH,TAPE9=BBLAS/M=R.
00260 GET,TAPE7=SCRSIT.
00270 SBULIM(JS=100)
00280 SCRLGO.
00290 SAVE,TAPE10=BSCRCST.
00295 REWIND,TAPE20.
00296 COPY,TAPE20,BSCR20.
00297 REWIND,TAPE30.
00298 COPY,TAPE30,BSCR30.
00299 REWIND,TAPE40.
00300 COPY,TAPE40,BSCR40.
00301 ENQUIRE,R.
00302 REWIND,OUTPUT.
00310 PURGE,BSCROUT/NA.
00320 DEFINE,BSCROUT.
00330 COPY,OUTPUT,BSCROUT.
00340 PURGE,BSCRDAY/NA.
00350 DEFINE,BSCRDAY.
00360 DAYFILE,BSCRDAY.
00370 EXIT.
00380 PURGE,BSCROUT/NA.
00390 DEFINE,BSCROUT.
00395 ENQUIRE,R.
00400 REWIND,OUTPUT.
00410 COPY,OUTPUT,BSCROUT.
00420 PURGE,BSCRDAY/NA.
00430 DEFINE,BSCRDAY.
00440 DAYFILE,BSCRDAY.
00460 /EOF
```

TABLE V-17. EXAMPLE OF SUBMITTING A BATCH RUN TO EXECUTE THE STMCAP PROGRAM; CHECKING THE JOB STATUS; AND CHECKING FOR CORRECT EXECUTION

```
 OLD,BSCR.
/SUBMIT,BSCR,N.
 10.25.59.ASIOBSG
/ENQUIRE,JN=BSG.
 ASIOBSG  IN INPUT QUEUE.
  .
  .
  .
/ENQUIRE,JN=BSG.
 ASIOBSG  NOT FOUND.
/ATTACH,BSCRDAY.
/LNH,FN=BSCRDAY.
 10.27.08.JOB,P4,T3000.
 10.27.09.ACCOUNT,USERNUM,,KC.
 10.27.09.ABG , P4.
 10.27.09.CHARGE,CHARG**,*SFX*PROJECTNO.
 10.27.09.PURGE,BSCR20/NA.
 10.27.09. BSCR20 NOT FOUND, AT 000121.
 10.27.10.PURGE,BSCR30/NA.
 10.27.10. BSCR30 NOT FOUND, AT 000121.
 10.27.10.PURGE,BSCR40/NA.
 10.27.10. BSCR40 NOT FOUND, AT 000121.
 10.27.10.PURGE,BSCRCST/NA.
 10.27.10.DEFINE,BSCR20.
 10.27.10.DEFINE,BSCR30.
 10.27.10.DEFINE,BSCR40.
 10.27.11.GET,INPUT=BSCROPT.
 10.27.11.GET,TAPE1=SASDAT6.
 10.27.11.GET,TAPE4=SCRPRC.
 10.27.11.GET,SCRLGO.
 10.27.12.GET,TAPE8=IUPLIME.
 10.27.13.ATTACH,TAPE9=BBLAS/M=R.
 10.27.13. BBLAS NOT FOUND,  AT 000121.
 10.27.14.EXIT.
 10.27.14.PURGE,BSCROUT/NA.
 10.27.14. BSCROUT NOT FOUND,  AT 000121.
 10.27.14.DEFINE,BSCROUT.
 10.27.14.ENQUIRE,R.
 10.27.14. ENQUIRY COMPLETE.
 10.27.14.REWIND,OUTPUT.
 10.27.14.COPY,OUTPUT,BSCROUT.
 10.27.15. END OF INFORMATION ENCOUNTERED.
 10.27.15.PURGE,BSCRDAY/NA.
 10.27.15.DEFINE,BSCRDAY.
 10.27.15.DAYFILE,BSCRDAY.
```

TABLE V-18. SAMPLE JOB STREAM TO EXECUTE THE TRANSPORTATION COST GENERATOR PROGRAM IN BATCH MODE (TRNCOST)

```
00000 /JOB
00100 JOB,P4,T1000.
00200 ACCOUNT,USERNUM,PASSWOR,KC.
00300 CHARGE,CHARGNO,*SFX*PROJNO.
00400 PURGE,BTRNCST/NA.
00500 DEFINE,TAPE4=BTRNCST.
00600 ATTACH,PSDLIB/UN=PSDRLIB.
00700 GET,TRNLGO.
00800 SBULIM(JS=500)
00900 LDSET(LIB=PSDLIB)
01000 TRNLGO.
01100 PURGE,BTRNOUT/NA.
01200 DEFINE,BTRNOUT.
01300 ENQUIRE,R.
01400 REWIND,OUTPUT.
01500 COPY,OUTPUT,BTRNOUT.
01600 PURGE,BTRNDAY/NA.
01700 DEFINE,BTRNDAY.
01800 DAYFILE,BTRNDAY.
01900 EXIT.
02000 PURGE,BTRNOUT/NA.
02100 DEFINE,BTRNOUT.
02200 ENQUIRE,R.
02300 REWIND,OUTPUT.
02400 COPY,OUTPUT,BTRNOUT.
02500 PURGE,BTRNDAY/NA.
02600 DEFINE,BTRNDAY.
02700 DAYFILE,BTRNDAY.
02800 /EOR
02900 X313H2S
03000 ITRNPTS
03100 /EOF
```

TABLE V-19. EXAMPLE OF SUBMITTING A BATCH RUN TO EXECUTE THE TRNCOST PROGRAM;

CHECKING THE JOB STATUS, AND CHECKING FOR CORRECT EXECUTION

```
 OLD,BTRN
/SUBMIT,BTRN,N.
 13.25.17.ASIOBNA
/ENQUIRE,JN=BNA.
 ASIOBNA IN INPUT QUEUE.
  .
  .
  .
/ENQUIRE,JN=BNA.
 ASIOBNA  NOT FOUND.
/ATTACH,BTRNDAY.
/LNH,FN=BTRNDAY.
 13.30.05.JOB,P4,T1000.
 13.30.05.ACCOUNT,USERNUM-,KC.
 13.30.05.ABG , P4.
 13.30.06.CHARGE,CHARG**,*SFX*PROJNO.
 13.30.06.PURGE,BTRNCST/NA.
 13.30.06.DEFINE,TAPE4=BTRNCST.
 13.30.06.ATTACH,PSDLIB/UN=PSDRLIB.
 13.30.07.GET,TRNLGO.
 13.30.07.SBULIM(JS=500)
 13.30.11.LDSET(LIB=PSDLIB)
 13.30.11.TRNLGO.
 13.36.01.    STOP
 13.36.01.PURGE,BTRNOUT/NA.
 13.36.01.DEFINE,BTRNOUT.
 13.36.01.ENQUIRE,R.
 13.36.01. ENQUIRY COMPLETE.
 13.36.01.REWIND,OUTPUT.
 13.36.01.COPY,OUTPUT,BTRNOUT.
 13.36.02. END OF INFORMATION ENCOUNTERED.
 13.36.02.PURGE,BTRNDAY/NA.
 13.36.02.DEFINE,BTRNDAY.
 13.36.02.DAYFILE,BTRNDAY.
```

TABLE V-20. SAMPLE JOB STREAM TO EXECUTE THE APEX LINEAR PROGRAMING PACKAGE AND THE REPORT GENERATOR PROGRAM (REPTSOL) IN DEFERRED BATCH MODE (OVERNIGHT) TO GENERATE AN EQUILIBRIUM MODEL SOLUTION AND A REPORT OF THE SOLUTION

```
00100 /JOB
00110 JOB,P2,T1500,CM101000.
00120 ACCOUNT,USERNUM,PASSWOR,KC.
00130 CHARGE,CHARGNO,*SFX*PROJECTNO.
00135 SBULIM(JS=1500)
00140 ATTACH,APEX/UN=LIBRARY.
00150 ATTACH,TAPE1=MODLIN.
00160 PURGE,APXRPT/NA.
00170 PURGE,MODLOUT/NA.
00180 DEFINE,APXRPT.
00190 DEFINE,MODLOUT.
00200 REDUCE(-)
00210 APEX(SOLVE,MIN,OBJ=COST,RL=1500,SOF=APXRPT,O=MODLOUT,PS)
00215 RETURN,MODLOUT.
00220 GET,RPGLGO.
00230 PURGE,BFINRPT/NA.
00240 DEFINE,TAPE4=BFINRPT.
00250 RFL,101000.
00260 RPGLGO.
00270 PURGE,BLPDAY/NA.
00280 PURGE,BLPOUT/NA.
00290 DEFINE,BLPOUT.
00300 ENQUIRE,R.
00310 REWIND,OUTPUT.
00320 COPY,OUTPUT,BLPOUT.
00330 DEFINE,BLPDAY.
00340 DAYFILE,BLPDAY.
00350 EXIT.
00360 PURGE,BLPDAY/NA.
00370 DEFINE,BLPDAY.
00380 DAYFILE,BLPDAY.
00390 PURGE,BLPOUT/NA.
00400 DEFINE,BLPOUT.
00410 ENQUIRE,R.
00420 REWIND,OUTPUT.
00430 COPY,OUTPUT,BLPOUT.
00440 /EOR
00450 MODLOUT
00460 (9-29-78 $.50 ACFL)
00470 IACDCST
00480 ISMLCST
00490 GENREPT
00500 /EOF
```

TABLE V-21. EXAMPLE OF SUBMITTING A DEFERRED BATCH RUN TO EXECUTE THE APEX PACKAGE AND REPTSOL PROGRAM TO SOLVE THE MODEL, GENERATE AN EQUILIBRIUM SOLUTION, AND PREPARE A REPORT OF THE SOLUTION

```
//
NET 051037
PLEASE SIGN ON--KC,USERNUM
 78/05/18.  12.41.32.
EASTERN CYBERNET CENTER SN147 NOS       1.0/411.477.0-0
PASSWORD
XXXXXXXX
TERMINAL:    305,TTY
RECOVER/ CHARGE: CHARGE,CHARGNO,*SFX*PROJECTNO
READY.
BATCH
$RFL,20000.
/OLD,BLPRPG
/SUBMIT,BLPRPG,N.
 12.42.10.ASIOBNZ
/ENQUIRE,JN=BNZ.
 ASIOBNZ IN INPUT QUEUE
/BYE

USERNUM LOG OFF  12.43.19.
SBU        0.667
TIO =    1779
```

TABLE V-22. CHECKING THE STATUS OF THE RUN SHOWN IN FIGURE V-19 AND SUBMITTED IN FIGURE V-20; THEN VERIFYING THE RESULTS

```
//
NET 051037
PLEASE SIGN ON--KC,USERNUM
 78/05/19. 09.41.32
EASTERN CYBERNET CENTER SN147 NOS          1.0/411.477.0-0
PASSWORD
XXXXXXXX
TERMINAL:    206,TTY
RECOVER/ CHARGE: CHARGE,CHARGNO,*SFX*PROJECTNO
READY
BATCH
$RFL,20000
/ENQUIRE,JN=BNZ.
 ASIOBNZ  NOT FOUND.
/ATTACH,BLPDAY.
/LNH,FN=BLPDAY.
 19.01.35.JOB,P2,T1500,CM101000.
 19.01.36.ACCOUNT,USERNUM,,KC.
 19.01.36.ABG , P2.
 19.01.36.CHARGE,CHARG**,*SFX*PROJECTNO.
 19.01.36.SBULIM(JS=1500)
 19.01.36.ATTACH,APEX/UN=LIBRARY.
 19.01.37.ATTACH,TAPE1=MODLIN.
 19.01.37.PURGE,APXRPT/NA.
 19.01.37.PURGE,MODLOUT/NA.
 19.01.37. MODLOUT NOT FOUND,  AT 000121.
 19.01.37.DEFINE,APXRPT.
 19.01.38.DEFINE,MODLOUT.
 19.01.38.REDUCE(-)
 19.01.38.APEX(SOLVE,MIN,OBJ=COST,RL=1500,SOF=APXR
 19.01.38.PT,O=MODLOUT,PS)
 19.01.44.ABD , APES    .
 19.01.46. *****************************
 19.01.46. **     O-O-C APEX-III      **
 19.01.46. **     WITH MIP OPTION     **
 19.01.46. **   WITH REDUCE OPTION    **
 19.01.46. ** WITH PARAMETRICS OPTION **
 19.01.46. *****************************
 19.56.27.AEB ,     208.588UNTS.
 19.56.27.      END  APEX
 19.56.27.RETURN,MODLOUT.
 19.56.27.GET,RPGLGO.
 19.56.28.PURGE,BFINRPT/NA.
 19.56.28.DEFINE,TAPE4=BFINRPT.
 19.56.28.RFL,101000.
 19.56.28.RPGLGO.
 19.57.38.     STOP
 19.57.38.PURGE,BLPDAY/NA.
 19.57.38.PURGE,BLPOUT/NA.
 19.57.38.DEFINE,BLPOUT.
 19.57.39.ENQUIRE,R.
 19.57.40.REWIND,OUTPUT.
 19.57.40.COPY,OUTPUT,BLPOUT.
 19.57.41.DEFINE,BLPDAY.
 19.57.41.DAYFILE,BLPDAY.
```

VI. REFERENCES

1. Waitzman, D. A., J. L. Nevins, and G. A. Slappey. Marketing H_2SO_4 from SO_2 Abatement Sources - The TVA Hypothesis. Bulletin Y-71, Tennessee Valley Authority, Office of Agricultural and Chemical Development, Muscle Shoals, Alabama. EPA-650/2-73-051, U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C., 1973. (NTIS PB 231 671)

2. Bucy, J. I., R. L. Torstrick, W. L. Anders, J. L. Nevins, and P. A. Corrigan. Potential Abatement Production and Marketing of Byproduct Sulfuric Acid in the U.S. Bulletin Y-122, Tennessee Valley Authority, Office of Agricultural and Chemical Development, Muscle Shoals, Alabama. EPA-600/7-78-070, U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C., 1978. (NTIS PB 284 200)

3. O'Brien, W. E., and W. L. Anders. Potential Production and Marketing of FGD Byproduct Sulfur and Sulfuric Acid in the U.S. - 1983 Projection. ECDP B-1, Tennessee Valley Authority, Office of Power, Emission Control Development Projects, Muscle Shoals, Alabama. In press.

4. McGlamery, G. G., R. L. Torstrick, W. J. Broadfoot, J. P. Simpson, L. J. Henson, S. V. Tomlinson, and J. F. Young. Detailed Cost Estimates for Advanced Effluent Desulfurization Processes. Bulletin Y-90, Tennessee Valley Authority, Office of Agricultural and Chemical Development, Muscle Shoals, Alabama. EPA-600/2-75-006, U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C., 1975. (NTIS PB 242 541)

APPENDIX A

INTEGRATED TRANSPORTATION DATA BASE

The byproduct marketing system was designed to provide a framework for modeling the market potential for FGD byproducts. Data bases and programs are maintained to allow projections of both supply and demand, including detailed estimates of the potential costs, quantities, and locations involved. However, no matter how refined any projections of potential supply and demand related to FGD byproducts may be, they are of limited value without corresponding projections of transportation costs.

A completely manual analysis of both the locations that must be considered and the appropriate shipping rates is a complex and time-consuming task. Specific supply sources, demand destinations, and the shipping distances between them must be known before the mode of shipment and the applicable rates can be determined. In the byproduct marketing system, the number of materials that shipping rates are required for is limited. However, the number of locations involved is not so limited and is constantly changing. Continuing analyses of market potential for those FGD byproducts that are currently modeled require the addition of new locations that must be taken into account along with locations previously considered. The analysis of market potential for additional FGD byproducts, produced from other scrubbing processes, can involve a completely different set of locations and shipping rates, for both the byproduct as well as any related materials.

A totally automated and generalized transportation system--including all rail, barge, and truck rates--would be a significant project in itself and prohibitive for byproduct marketing purposes. However, by limiting such a system to a location data base, with shipping rates determined separately and limited to those required for the byproduct marketing system alone, the necessary resources are more practical and could be very cost effective in the long run.

A transportation location data base was created using the System 2000 format (related manuals are shown in Appendix B). A description is shown in Table A-1 and should be referred to as necessary throughout the remainder of this appendix. The data base contains all named locations in the 48 contiguous states that could be considered for shipping by rail, barge, or truck. Every location that could be identified from any source is included; no location was intentionally omitted no matter how small.

TABLE A-1. TRANSPORTATION LOCATION DATA BASE

```
DATA BASE NAME IS USLOCAT

 100*  FIPS-STATE (INTEGER NUMBER 99)
 110*  STATE-ABBREVIATION (NAME XX)
 120*  STATE-NAME (NON-KEY NAME X(15))
 200*  COUNTY-RG (RG)
   210*  FIPS-COUNTY (INTEGER NUMBER 999 IN 200)
   220*  COUNTY-NAME (NON-KEY NAME X(30) IN 200)
   230*  MEAN-LATITUDE (NON-KEY DECIMAL NUMBER 99.99 IN 200)
   240*  MEAN-LONGITUDE (NON-KEY DECIMAL NUMBER 999.99 IN 200)
   250*  SQ-MILE-AREA (NON-KEY INTEGER NUMBER 9(6) IN 200)
   260*  N-LATITUDE (NON-KEY DECIMAL NUMBER 99.99 IN 200)
   270*  S-LATITUDE (NON-KEY DECIMAL NUMBER 99.99 IN 200)
   280*  E-LONGITUDE (NON-KEY DECIMAL NUMBER 999.99 IN 200)
   290*  W-LONGITUDE (NON-KEY DECIMAL NUMBER 999.99 IN 200)
   310*  FUTURE-GROWTH (NON-KEY NAME X(100) IN 200)
   500*  LOCATIONS-RG (RG IN 200)
     510*  LOCATION-SPLC (INTEGER NUMBER 9(6) IN 500)
     520*  LOCATION-NAME (NON-KEY NAME X(32) IN 500)
     525*  COUNTY-SEAT (NON-KEY NAME X IN 500)
     530*  ZIP-CODE (INTEGER NUMBER 9(5) IN 500)
     540*  LATITUDE (DECIMAL NUMBER 99.99 IN 500)
     550*  LONGITUDE (DECIMAL NUMBER 999.99 IN 500)
     560*  RAIL-SPLC (INTEGER NUMBER 9(6) IN 500)
     570*  MILES-TO-RAIL (NON-KEY DECIMAL NUMBER 9999.9 IN 500)
     580*  BARGE-SPLC (INTEGER NUMBER 9(6) IN 500)
     590*  MILES-TO-BARGE (NON-KEY DECIMAL NUMBER 9999.9 IN 500)
     610*  RATE-BASIS-SPLC (INTEGER NUMBER 9(6) IN 500)
     615*  RATE-BASIS-NAME (NON-KEY NAME X(32) IN 500)
     620*  RAIL-MILEAGE-INDEX (NON-KEY DECIMAL NUMBER 99.99 IN 500)
     630*  RAIL-TARIFF-INDEX (NON-KEY INTEGER NUMBER 99 IN 500)
     700*  RAIL-STATIONS-RG (RG IN 500)
       740*  NRBT-ITEM-NUMBER (NAME X(10) IN 700)
       750*  CARRIER (NAME XXXX IN 700)
       760*  STATION (TEXT X(8) IN 700)
       770*  FOOTNOTE (NAME XXXX IN 700)
       780*  SUPPLEMENT (NAME XXXX IN 700)
       790*  CANCEL (NAME X IN 700)
     800*  BARGE-RG (RG IN 500)
       810*  BARGE-NODE (INTEGER NUMBER 9(10) IN 800)
       820*  MILES-TO-CAIRO (NON-KEY DECIMAL NUMBER 9999.9 IN 800)
       830*  MILES-TO-HRVY-LOCKS (NON-KEY DECIMAL NUMBER 9999.9 IN 800)
       840*  TVA-BARGE-NODE (NON-KEY INTEGER NUMBER 9(7) IN 800)
       850*  TENN-TOM (NON-KEY DECIMAL NUMBER 9999.9 IN 800)
```

All locations are grouped by state and county. State information is at the first level of the data base and county information is at the second level. Location-specific information is at the third level in the data base structure. A location repeating group was established for every point that could be identified as being either a rail-related location (stations, rate basing points), a barge-related location, or simply a named geographic location. Although many locations were established solely on the basis of rail or barge data, all locations are assumed to be generally accessible by truck.

Rail and barge information is at the fourth (and lowest) level in the data base structure. Each location that is a rail shipping point or a barge shipping point has a corresponding rail station or barge repeating group (component numbers 700 and 800 respectively). The information necessary to determine rail mileages within the Docket 28300 area (see Appendix C) is provided by component 620. Barge shipping mileages can be determined directly from components 810, 820, and 830.

The transportation location data base contains over 26 million characters. In addition to all of the states and counties, there are over 100,000 truck points, over 20,000 rail stations that are associated with the various rail carriers, and almost 2,000 barge terminals on the navigable inland waterway system.

After the data base was created, for those locations that are not rail or barge points, the nearest rail shipping point and the nearest barge shipping point were to have been determined. The resulting data could then have been used to update the original data base components 560-630 (locations that are rail or barge points would have zero for components 570 or 590). However, original estimates of the computer charges that would be incurred for such an update were based on a relatively small data base. Test cases using the actual data base indicated that computer charges for the update would be many times higher than originally estimated, and prohibitive based on potential benefits to the byproduct marketing system alone.

The final step of linking all locations by truck, rail, barge, or any combination of the three could have significantly reduced the effort necessary to determine required location information in the transportation cost generator. For any combination of locations, an automated procedure could have been developed to use the data base information and select the mode (or modes) of shipment and the distance involved. The rail rate selection procedure is already automated and a similar procedure could have been developed for barge and truck rates.

Because the final step has still not been completed, usage of the transportation location data base in the system has not been automated. Requirements in the future may justify linking all truck, rail, and barge points and automating the shipping point location procedure. The primary reason for including the information in this appendix is that benefits may be realized by using the data base in other systems in the current form.

APPENDIX B

RELATED CYBERNET MANUALS AND PUBLICATIONS

Publication	Publication No.
CYBERNET Interactive Service Reference Set	
Vol 1, Tutorial	84000320
Vol 2, Interactive Usage	84000360
Vol 3, Comprehensive Usage	84000370
CYBERNET Services XEDIT User Information Manual	76071000
CYBERNET Services FORTRAN Extended 4 Reference Manual	84000009
CYBERNET Interactive Service Compiler Subroutine and Function Supplement	84002000
APEX-III Reference Manual	76070000
CYBERNET Services SYSTEM 2000	
User Information Manual	76074000
System Support Manual	76074900
Procedural Language Interface (PLI)	76075000
Immediate Access	76074400
CYBERNET Services SCOPE 3.4 Reference Manual	84000021
CYBERNET Services SCOPE 2.1 Reference Manual (This publication covers CYBER 76 Services)	84000230
CYBERNET Services CYBERLINK Communications Interchange Users Guide	84000120

Note: These publications are distributed by Control Data Corporation, Minneapolis, Minnesota.

APPENDIX C

RAIL MILEAGE FILE DESCRIPTION AND USAGE

TRIANGULAR MILEAGE FILE

A primary requirement in the byproduct marketing system was the development of rail mileages that are used to determine rail rates. These rail mileages are used as a part of avoidable acid production cost calculations and, more importantly, in the transportation subsystem to determine rail costs associated with shipping from power plants and smelters to acid plants for all of the possible combinations to be considered in the linear programing marketing model. Rail rates are based on 2632 rate basing points that are considered as possible source and destination locations. In many cases, a minimum mileage for rate determination purposes is defined even when the source and destination rate basing points are the same. This occurs because the 2632 rate basing points in the Docket 28300 area are not specific point locations but represent general geographic areas which can be fairly large.

The number of mileage entries required for 2632 rate basing points considered as either sources of shipments or destinations of shipments is 2632 x 2632, or 6,927,424. The costs associated with a data file containing 6,927,424 mileage entries, both on a data storage basis and a data access basis, require careful consideration. A common requirement is the comparison of the shipping costs between various source points and all possible destination points. Therefore the number of file accesses for required mileages must be kept to a minimum without significantly increasing the number of mileage entries in the file.

A triangular mileage table concept was used to build a file of all possible mileage entries required. For any number of locations, n, to be considered, a table can be constructed such that given a source location number, i, and a destination location, j, the mileage between the two, M(i,j), can be read directly from the table. Table C-1 is an example of such a table.

However, even though Table C-1 contains the mileage from any location to all other possible locations (including itself) the number of entries has not been minimized. Consider the mileage from location 1 to location 2, M(1,2), and the mileage from location 2 to location 1, M(2,1). The distance between the points is the same whether point 1 is the source or destination. If a requirement is established that anytime point 1 is to be considered in a mileage table search it will always be

TABLE C-1. GENERAL MILEAGE TABLE

Destination numbers

Source numbers

	1	2	3	...	n - 1	n
1	M(1,1)	M(1,2)	M(1,3)	...	M(1,n - 1)	M(1,n)
2	M(2,1)	M(2,2)	M(2,3)	...	M(2,n - 1)	M(2,n)
3	M(3,1)	M(3,2)	M(3,3)	...	M(3,n - 1)	M(3,n)
...	...	...	...	...	...	...
n - 1	M(n - 1,1)	M(n - 1,2)	M(n - 1,3)	...	M(n - 1,n - 1)	M(n - 1,n)
n	M(n,1)	M(n,2)	M(n,3)	...	M(n,n - 1)	M(n,n)

considered the source, then all entries in column 1 except M(1,1) can be removed. For example, M(2,1), M(3,1), . . . , M(n,1) can also be found at M(1,2), M(1,3), . . . , M(1,n). The entry for M(1,1) cannot be removed because a minimum mileage may be specified even though the source and destination rate basing points are the same. In column 2 the same principle can be applied. The first entry, M(1,2), must be kept because M(2,1) was removed from the first column and M(1,2) is now the only entry for points 1 and 2. The second entry, M(2,2), is required just as M(1,1) was required. In the case of M(3,2), the same mileage can be found at M(2,3). The same is true for M(4,2), M(5,2), . . . , M(n,2). As in columns 1 and 2, in column 3 all entries below M(3,3) can be removed. By examining the number of entries that could be removed in each column, a pattern can be established. In column 1, all entries in the column except the first one, M(1,1), can be removed. If there were originally n entries, then n - 1 entries can be removed. In column 2, all entries except M(1,2) and M(2,2) can be removed. If there were n entries, then n - 2 entries can be removed. In column 3 all except the first three entries can be removed, or n - 3. In column 4, n - 4 can be removed, etc.

In the table of rate basing points n = 2632. Therefore n - 1 entries removed from column 1 is 2632 - 1 or 2631; in column 2, n - 2 = 2632 - 2; in column 3, n - 3 = 2632 - 3; . . . ; in column n - 1, n - (n - 1) = 2632 - 2631; and finally, in column n, n - n = 2632 - 2632, or zero. Examination of Table C-1 will show why no entries can be removed from the last column. M(n,n) is the last entry in the last column, and all entries above it are required just as M(1,1), M(2,2), M(3,3), etc., were required. Table C-2 shows all possible entries removed from the original Table C-1. The entries in Table C-2 form a triangle and are the basis for the term, triangular mileage table.

TABLE C-2. TRIANGULAR MILEAGE TABLE

Destination numbers

Source numbers

	1	2	3	...	n - 1	n
1	M(1,1)	M(1,2)	M(1,3)	...	M(1,n - 1)	M(1,n)
2		M(2,2)	M(2,3)	...	M(2,n - 1)	M(2,n)
3			M(3,3)	...	M(3,n - 1)	M(3,n)
...				...	...	...
n - 1					M(n - 1, n - 1)	M(n - 1,n)
n						M(n,n)

The number of entries that remain in each column is exactly equal to the column number, so the total number of entries is 1 + 2 + 3 + 4 + . . . + (n - 1) + n. A formula can be used to calculate the total number of entries required in a triangular table such as Table C-2.

$$\text{Entries required} = \frac{n(n + 1)}{2}$$

In the case of the rate basing point mileages, n is 2632.

$$\text{Entries required} = \frac{(2632)(2633)}{2}$$

All entries in Table C-2 are required; no more can be removed and still provide all mileage possibilities. The original Table C-1 contained 6,927,424 mileage entries. Table C-2 contains only 3,465,028 mileage entries so the number of mileages required has been reduced by almost 50%.

With the number of table entries minimized, the mileage entries could be written to a sequential data file by indexing through the table and writing a data record for each mileage entry beginning with column 1, then column 2, column 3, etc. Table C-3 shows the relative entry number (EN) of each mileage entry written to the data file. The EN of each mileage entry record in the data file can be calculated directly by the following formula, where i is the row rate basing point number (source) and j is the column rate basing point number (destination).

TABLE C-3. SAMPLE RELATIVE MILEAGE ENTRY RECORD NUMBER

FOR A TRIANGULAR MILEAGE DATA FILE

	Destination rate basing points					
Source rate basing points	1	2	3	...	2631	2632
1	EN1	EN2	EN4	...	EN3459766	EN3462397
2		EN3	EN5	...	EN3459767	EN3462398
3			EN6	...	EN3459768	EN3462399
...				...	...	...
2631					EN3462396	EN3465027
2632						EN3465028

$$EN(i,j) = i + j(j - 1)/2$$

The following example shows how to determine which EN contains the mileage from rate basing point 3 to rate basing point 2, or M(3,2). In order to develop a triangular table in the first place, almost half of the mileage entries were removed by always accessing with the lowest rate basing point number first. Examination of the mileage M(3,2) shows that before the mileage entry can be found, the source and destination must be reversed, i.e., M(2,3). Now the formula can be used:

$$EN(i,j) = i + j(j - 1)/2$$

$$= 2 + 3(2)/2$$

$$= 5$$

The mileage entry for M(2,3) is the fifth mileage entry, which can be verified by referring to Table C-3.

If the only requirement had been the minimum number of mileage entries, a file could be written as just described and would be the smallest possible size. However, when rate comparisons are required and the distance from several rate basing points to all other rate basing points must be found, the number of file accesses would be prohibitive. For a single rate basing point, finding the mileage records for distances to all other points (including itself) requires 2632 file accesses. If the mileages from 50 points are to be compared, getting all possible distances from the 50 points to all other points requires 50 x 2632 = 131,600 file accesses. To reduce the number of file accesses, some blocking technique is required so that a single file access will get a block of mileage entries rather than only one entry.

In the current file, a blocking factor (BF) of 50 was chosen, and each block contains 50 x 50 or 2500 mileage entries. Because 2632 is not evenly divisible by 50, 2650 points were provided in the blocked file, with the additional 18 points allowed for future expansion before the file size will have to be increased. Instead of a file of individual mileage records for 2632 rate basing points, there is now a file of blocked mileage records for 2650 rate basing points and each block contains 2500 individual mileage entries. The file size is now n(n + 1)/2 = 2650(2651)/2, or 3,512,575 entries. However, instead of requiring 2632 file accesses to find the mileage entries from one point to all other points, only 53 (2650/50 = 53) accesses are required because each block contains mileages from 50 points to 50 other points. The potential reduction in file accesses is from 2632 to 53 (about 98%). The increase in file size is from 3,465,028 entries for 2632 points to 3,512,575 entries for 2650 points (about 1.5%). The triangular blocked table and the relative block number (BN) of each block are shown in Table C-4.

The formula to calculate the total number of blocks required is the same as for calculating the total number of entries required except instead of n = 2632 or n = 2650, n = 53.

$$\text{Blocks required} = n(n + 1)/2$$

$$= 53(53 + 1)/2$$

$$= 1431$$

The BN that contains a particular mileage entry can be found in the same manner that an EN was found before blocking the data except that the BF must now be considered. As an example, assume that the distance from source rate basing point number 57 to destination rate basing point number 102 must be found using the blocked file, i.e., find M(57,102).

TABLE C-4. BLOCKED TRIANGULAR MILEAGE TABLE

Destination blocks

Source blocks

	1	2	3	...	52	53
1	BN1	BN2	BN4	...	BN1327	BN1379
2	X	BN3	BN5	...	BN1328	BN1380
3	X	X	BN6	...	BN1329	BN1381
...	X	X	X	...	...	...
52	X	X	X	X	BN1378	BN1430
53	X	X	X	X	X	BN1431

The first step is to determine the row block and column block that contains the mileage to be found. Each block contains 50 x 50 mileage entries, and based on Tables C-3 and C-4 shown previously, block 1 contains mileages from row rate basing points 1-50 to column rate basing points 1-50; block 2 contains mileages from row rate basing points 1-50 to column rate basing points 51-100; block 3 contains mileages from row rate basing points 51-100 to column rate basing points 51-100, etc. The row block index (RBI) and column block index (CBI) of the block that contains the mileage entry for source rate basing point i and destination rate basing point j can be found by using the following formulas:

$$RBI(i,j) = [(i - 1)/BF] + 1$$

$$CBI(i,j) = [(j - 1)/BF] + 1$$

where $(i - 1)/BF$ and $(j - 1)/BF$ are always integer quotients; any remainder is discarded. Table C-4 was based on a BF of 50 and the RBI and CBI for $M(57,102)$ are found as follows:

$$\begin{aligned} RBI(57,102) &= [(57 - 1)/50] + 1 \\ &= (56/50) + 1 \\ &= 2 \end{aligned}$$

The mileage entry is in the second row of blocks.

$$\begin{aligned} CBI(57,102) &= [(102 - 1)/50] + 1 \\ &= (101/50) + 1 \\ &= 3 \end{aligned}$$

The mileage entry is in the third column of blocks.

To calculate the BN based on the RBI and the CBI, the procedure is the same as determining the EN in Table C-3. The BN is calculated using the RBI and CBI instead of the i and j values in the unblocked table. Instead of

$$EN(i,j) = i + j(j - 1)/2$$

the following formula is used:

$$\begin{aligned} BN(i,j) &= RBI + CBI(CBI - 1)/2 \\ &= 2 + 3(2)/2 \\ &= 5 \end{aligned}$$

The BN containing M(57,102) is 5. This can be verified by examination of Tables C-3 and C-4. Row block 2 contains all row source points 51-100, so it contains point 52. Column block 3 contains all column destination points 101-150, so it contains 102. The intersection of row block 2 and column block 3 is BN 5.

To find the particular mileage within the block once the BN is known, a combination of the rate basing point row number, the rate basing point column number, the RBI, and the CBI must be used to determine the row and column within the block (each block is BF rows x BF columns; in this case 50 rows by 50 columns). The RBI within the block (BRBI) and the CBI within the block (BCBI) are calculated as follows:

$$BRBI(i,j) = i - (RBI - 1)BF$$

$$BCBI(i,j) = j - (CBI - 1)BF$$

Using the previous example of M(57,102),

$$\begin{aligned} BRBI(57,102) &= 57 - (2 - 1)50 \\ &= 7 \end{aligned}$$

$$\begin{aligned} BCBI(57,102) &= 102 - (3 - 1)50 \\ &= 2 \end{aligned}$$

M(57,102) is in row 7, column 2, within the block. The block entry number (BEN) is the equivalent of the EN in the unblocked file except that it is now limited to a single block. It can be calculated using the BRBI, the BCBI, and the BF.

$$BEN = BRBI + BF(BCBI - 1)$$

$$= 7 + 50(1)$$

$$= 57$$

M(57,102) is the 57th mileage entry in BN 5.

When the file of mileage values is created, each block is written so that it can be read directly using the BN as a key. By following the steps in the preceding discussion the mileage between any two rate basing points can be retrieved from the file. (If mileage entries to all other rate basing points are required, all 53 blocks are processed in the same way.) As the blocks are read from the file, 50 mileage entries are taken from each block with only one file access per block. The complete procedure is reviewed in the following example:

Find the mileage entry from the blocked triangular mileage file between rate basing points 1708 and 29, M(1708,29).

1. For the mileage M(i,j) between locations i and j, i must be $\leq$j so calculations should be for M(29,1708)

2. The RBI and CBI must be calculated

   a. $RBI(i,j) = [(i - 1)/BF] + 1$

      $RBI(29,1708) = [(29 - 1)/50] + 1$

      $RBI(29,1708) = 1$

   b. $CBI(i,j) = [(j - 1)/BF] + 1$

      $CBI(29,1708) = [(1708 - 1)/50] + 1$

      $CBI(29,1708) = 35$

      M(29,1708) is in row block 1 and column block 35

3. The BN must be calculated

   $BN(i,j) = RBI + CBI(CBI - 1)/2$

   $BN(29,1708) = 1 + 35(35 - 1)/2$

   $BN(29,1708) = 596$

   M(29,1708) is in BN 596

4. BN 596 (2500 entries) is read from the triangular mileage file

5. The row index and column index within the block must be found

   a. BRBI(i,j) = i - (RBI - 1)BF

      BRBI(29,1708) = 29 - 1(1 - 1)50

      BRBI(29,1708) = 29

   b. BCBI(i,j) = j - (CBI - 1)BF

      BCBI(29,1708) = 1708 - (35 - 1)50

      BCBI(29,1708) = 8

      M(29,1708) is in the 29th row and 8th column within block 596

6. The entry within the block must be calculated

   BEN(i,j) = BRBI + BF(BCBI - 1)

   BEN(29,1708) = 29 + 50(8 - 1)

   BEN(29,1708) = 379

   M(29,1708) is the 379th entry of block 596

Table C-4 showed the triangular blocked table format. However, (refer to Table C-2) the blocks along the diagonal do not contain 50 x 50 or 2500 valid mileage entries. Each block on the diagonal is actually triangular, and contains only 50(50 + 1)/2 = 1275 valid mileages. Rather than treat each block along the diagonal as a special case which would involve variable length blocks and a more complex file generation and accessing technique, the blocks along the diagonal are written just as though all entries were valid. The same procedures still apply; the only effect is 1225 empty mileage entries written per block on the diagonal. Since there are 53 blocks on the diagonal, there are 53 x 1225 = 64,925 empty entries included in the file. The blocked file contained a minimum number of 3,512,575 entries; the addition of 64,925 entries to avoid the problems described above is only a 1.9% increase in the file size. The following paragraph summarizes the file development process up to this point.

The original triangular mileage tables (Tables C-2 and C-3) contained a minimum number of mileage entries, 3,465,028, but required 2,632 file accesses to retrieve mileage entries from one point to all other points (including itself). A blocking technique was developed that only increased the minimum table size by 112,472 or 3.2% (47,547 entries, or a 1.3% increase, resulted from the addition of 18 points because of the BF of 50; and 64,925 entries, or a 1.9% increase, resulted from including empty entries in the diagonal blocks to avoid variable length blocks). By increasing the file size 3.2%, a potential reduction in file accesses of up to 98% resulted (from 2632 to 53), a more than acceptable trade off. (The file size is verified by considering 1431 blocks, each containing 2500 entries. 1,431 x 2,500 = 3,577,500, and is the same as 3,465,028 + 27,547 + 64,925.)

TRIANGULAR MILEAGE FILE (CDC FORMAT)

Four factors were taken into account to develop the rail mileage file on the CDC system. One factor was the number of file accesses required. As discussed previously, a blocked data file was used to reduce the number of potential file accesses. The remaining factors were on-line storage requirements for the total file, core storage requirements for retrieval programs (one block of the file), and data conversion requirements.

Using a standard decimal format for the rail mileage data results in problems with all three of the factors not previously considered. Each mileage entry requires up to 4 decimal characters, and based on 3,577,500 entries, 4 characters per entry, an on-line storage file size of 14,310,000 characters would be required. On the CDC CYBERNET system, a 60-bit, 10-character word internal format is used. Even though each mileage entry is a maximum of 4 characters, a standard FORTRAN integer variable requires a full 10-character word. Based on 2,500 mileage entries per block, 10 characters per entry, 25,000 characters of core storage would be required to contain one block of data in a program. Finally, all decimal data requires a conversion each time it is transferred between the external format of on-line storage and the internal format required within a program. Ease of program use is the only advantage of a decimal format. Standard data input and output routines can be used to read or write a block of mileages and the required mileage entry can be directly extracted from the block by subscripting.

A binary format reverses the disadvantages and advantages of a decimal format. Although each mileage entry requires 4 decimal characters, no mileage entry is greater than 4,095. If a value never exceeds 4,095 decimal, then it can be represented by a maximum of 12 binary bits ($4095_{10} = 7777_8 = 111111111111_2$). This is the equivalent of only 2 decimal characters, and 5 mileage entries can be packed into a single 60-bit, 10-character word. For 3,577,500 mileage entries, 2 characters per entry, an on-line storage file size of 7,155,000 characters would be required, only 50% of the size required for a decimal format. Core storage requirements for a program would be 5000 characters (2500 entries per block, 2 characters per entry), only 20% of the size required for a decimal format. There would be no data conversion for a binary format; binary data do not require conversion when transferred between on-line storage and a program. The only disadvantage of using the binary format is additional complexity for program usage. Standard read and write routines cannot be used and a mileage entry cannot be extracted from a block by subscripting alone. Based on the preceding comparisons between decimal and binary format and the factors that were to be considered, a binary format was selected for the rail mileage file on the CDC system.

Packing of mileage entries into 12 bits, 5 per word, is in the same sequence that entries would be written to a blocked file (and also to the original sequential file), that is, in column order. Table C-4 showed the triangular blocked file. Because block 1 is on the diagonal and contains empty entries, block 2 will be used as an example. The same principle applies to all blocks, including those on the diagonal, but the empty entries make the patterns more difficult to illustrate. Table C-5 shows the mileage entries in block 2. Block 2 is in the first row of blocks so the rate basing point rows in block 2 are 1-50. However, block 2 is in the second column of blocks so the rate basing point colums in block 2 are 51-100. Blocks in the second row of blocks (such as block 3 of Table C-4) contain row rate basing points 51-100.

TABLE C-5. BLOCK 2 OF TABLE C-4, BY ENTRY NUMBER

Column rate basing points

Row rate basing points

	51	52	53	54	55	56	...	100
1	EN1276	EN1327	EN1379	EN1432	EN1486	EN1541	...	EN4951
2	EN1277	EN1328	EN1380	EN1433	EN1487	EN1542	...	EN4952
3	EN1278	EN1329	EN1381	EN1434	EN1488	EN1543	...	EN4953
4	EN1279	EN1330	EN1382	EN1435	EN1489	EN1544	...	EN4954
5	EN1280	EN1331	EN1383	EN1436	EN1490	EN1545	...	EN4955
6	EN1281	EN1332	EN1384	EN1437	EN1491	EN1546	...	EN4956
...	...	...	...	...	...	...	...	...
50	EN1325	EN1376	EN1428	EN1481	EN1535	EN1590	...	EN5000

Because block 1 (which is just to the left of block 2 in Table C-4) is a diagonal block the only valid mileage entries are EN1 through EN1275, so the first entry in block 2 is EN1276. Block 2 is not a diagonal block so it contains 2500 valid entries, from EN1276, M(1,51) (the distance from rate basing point 1 to rate basing point 51) to EN5000, M(50,100) (the distance from rate basing point 50 to rate basing point 100). The entry numbers in the block are not EN1276 through EN3776 (1276 + 2500) because column entries continue from block 2 into block 3 which is just below (see Tables C-4 and C-5). The block contains entries in column order (EN1276, EN1277, EN1278, etc.), and is the order used to pack them into 60-bit words, 12 bits per entry. The first word of block 2 contains EN1276, EN1277, EN1278, EN1279, EN1280. The second word contains EN1281, EN1282, EN1283, EN1284, EN1285, etc. Word 1 of block 2 is shown below:

Word 1

Entry number	EN1276	EN1277	EN1278	EN1279	EN1280
Bit number	59...48	47...36	35...24	23...12	11...0

Within the word, bits are numbered in reverse order, so EN1276 is in the leftmost 12 bits of the word that are numbered 48-59. Five entries are packed per word and each column in a block contains 50 entries, so 10 words are required per column. There are 50 columns per block and 10 words are required per column, so 500 words are required per block. Table C-6 shows block 2 represented by relative word number (WN) rather than by mileage entry. Each word shown in Table C-6 contains five separate mileage entries.

The calculations required to extract a mileage from the triangular mileage file are still basically the same as described earlier. The difference is that instead of finding the EN within the block that is read and using it to directly extract the required entry from the program array containing the mileage block, not only the EN within the block must be found, but the word containing the entry and also the position of the entry within the word must be found. Before using the binary format and packing five entries per word, the EN and the word within the block were the same because each entry occupied a full word in the program array. The EN and the word within the block are no longer the same and an additional mask and shift operation is required because a standard subscript identifies an entire word, not bit positions within a word. The calculations required to extract a mileage entry from the blocked triangular file remain the same except that each subscript number identifies a word with five mileage entries. The mask and shift operation is used to identify a single mileage entry within the word.

TABLE C-6. BLOCK 2 OF TABLE C-4, BY WORD NUMBER

(See also Table C-5)

Rate basing point columns

Rate basing point words

	1	2	3	4	...	49	50
1	WN1	WN11	WN21	WN31	...	WN481	WN491
2	WN2	WN12	WN21	WN32	...	WN482	WN492
3	WN3	WN13	WN22	WN33	...	WN432	WN493
4	WN4	WN14	WN23	WN34	...	WN433	WN494
...	...	...	...	...	...	...	...
9	WN9	WN19	WN29	WN39	...	WN489	WN499
10	WN10	WN20	WN30	WN40	...	WN490	WN500

In order to do the mask and shift, the WN must be calculated using the BEN, dividing by 5 because there are 5 entries per word.

$$\mathrm{WN}(i,j) = [(\mathrm{BEN} - 1)/5] + 1$$

where (BEN - 1)/5 is an integer quotient.

As a continuation of the earlier example where the mileage entry M(57,102) was to be found, a BN of 5 had been calculated, and within BN 5, a BEN in the unpacked file was found to be 57. M(57,102) is still in BEN 57 of block 5, which is the 57th mileage entry in the block, but in the packed file it is no longer the 57th word. The WN must be calculated using the BEN.

$$\mathrm{WN}(i,j) = [(\mathrm{BEN} - 1)/5] + 1$$

$$\mathrm{WN}(57,102) = [(57 - 1)/5] + 1$$

$$\mathrm{WN}(57,102) = 12$$

The mileage entry for M(57,102) is in WN 12 of block 5. Word 12 can now be extracted from the array using 12 as a subscript, but word 12 actually contains five mileage entries. If MILARY is the variable name of the mileage array containing the required block, then

MILARY(WN) =

M(i,j)	M(i + 1,j)	M(i + 2,j)	M(i + 3,j)	M(i + 4,j)

In order to determine which of the five entries within the word contains the desired mileage, the word entry number (WEN) must be calculated, which is the relative entry position within word WN.

$$\mathrm{WEN}(i,j) = [\mathrm{MOD}(\mathrm{BEN} - 1),5] + 1$$

where MOD is a modulo function with respect to the number of entries per word, which is five. Continuing with M(57,102), which had a BEN of 57 in block 5

$$\mathrm{WEN}(i,j) = [\mathrm{MOD}(\mathrm{BEN} - 1),5] + 1$$

$$\mathrm{WEN}(57,102) = [\mathrm{MOD}(57 - 1),5] + 1$$

$$\mathrm{WEN}(57,102) = 1 + 1$$

$$\mathrm{WEN}(57,102) = 2$$

M(57,102) is in the second 12 bits from the left of word 12 of block 5.

MILARY(12) =

M(56,102)	M(57,102)	M(58,102)	M(59,102)	M(60,102)

To extract the appropriate entry from the word, a series of masks must be defined, with the mask number used dependent upon which 12 bits contain the desired entry.

MASK(1) = 77770000000000000000

MASK(2) = 00007777000000000000

MASK(3) = 00000000777700000000

MASK(4) = 00000000000077770000

MASK(5) = 00000000000000007777

The mask number that will be used is determined by the WEN calculated above.

MASK(n) = MASK(WEN)

If the word within the block that contains the desired mileage, and the appropriate mask, based upon the value of WEN, is used in a logical AND operation, the result will be that the other four entries will be excluded by being set to zero, leaving the desired mileage entry as the only nonzero value within the word. A new variable (MENTRY for example) is used to contain the results of the AND operation to avoid destroying the other four entries in the word. These other entries may be required in subsequent mileage searches and if they are destroyed, the complete block must be read into the array again from storage. By placing the results of the AND operation into a new variable, WN of the block is unchanged and the unused entries are still available if needed in subsequent mileage extractions.

MENTRY = MILARY(WN).AND.MASK(WEN)

Continuing with M(57,102)

MENTRY = MILARY(WN).AND.MASK(WEN)

MENTRY = MILARY(12).AND.MASK(2)

The operation can be illustrated as follows:

MILARY(12)	M(56,102)	M(57,102)	M(58,102)	M(59,102)	M(60,102)

and

MASK(2)	0000	7777	0000	0000	0000

=

MENTRY	0000	M(57,102)	0000	0000	0000

The desired mileage entry is now the only value in word MENTRY, but before it can be used it must not only be the only data in the word, it must be the rightmost 12 bits of the word. In the CDC system, a left end around shift can be used to move the desired 12 bits into the rightmost part of the word, with the number of bits shifted (in increments of 12) dependent upon the original position of the entry within the word.

$$M(i,j) = \text{SHIFT }[\text{MENTRY},12(\text{WEN})]$$

For M(57,102)

$$M(i,j) = \text{SHIFT }[\text{MENTRY},12(\text{WEN})]$$

$$M(57,102) = \text{SHIFT }[\text{MENTRY},12(2)]$$

$$M(57,102) = \text{SHIFT }(\text{MENTRY},24)$$

$$M(57,102) = \text{MENTRY}$$

The shift function will execute a left end around shift of 24 bits for M(57,102). A shift of 12 bits will move the 12 bits containing the mileage entry into the leftmost 12 bits of word MENTRY; the remaining 12-bit shift will move the 12 bits out the left end of the word and back into the rightmost 12 bits of the word; and after the shift is completed, M(57,102) will be the value of MENTRY which can now be used as a normal variable.

MENTRY	0000	0000	0000	0000	M(57,102)

The following example illustrates the complete process required to extract the mileage between two rate basing points from the blocked triangular mileage file of packed binary entries. Find the mileage between rate basing point 1793 and rate basing point 231; M(1793,231). Because of the triangular design, instead of M(1793,231), M(231,1793) should be found. The first step is to determine the row block and column block by calculating the RBI and CBI.

$$\text{RBI}(i,j) = [(i - 1)/\text{BF}] + 1$$

$$\text{RBI}(231,1793) = [(231 - 1)/50] + 1$$

$$\text{RBI}(231,1793) = 5$$

$$\text{CBI}(i,j) = [(j - 1)/\text{BF}] + 1$$

$$\text{CBI}(231,1793) = [(1793 - 1)/50] + 1$$

$$\text{CBI}(231,1793) = 36$$

M(231,1793) is in row block 5 and column block 36.

$$\mathrm{BN}(i,j) = \mathrm{RBI} + \mathrm{CBI}(\mathrm{CBI} - 1)/2$$

$$\mathrm{BN}(231,1793) = 5 + 36(35)/2$$

$$\mathrm{BN}(231,1793) = 635$$

M(231,1793) is in BN 635.

BN 635 is read into the program from the rail mileage file. The row number within block 635 and the column number within block 635 that contains M(231,1793) must be found.

$$\mathrm{BRBI}(i,j) = i - (\mathrm{RBI} - 1)\mathrm{BF}$$

$$\mathrm{BRBI}(231,1793) = 231 - (5 - 1)50$$

$$\mathrm{BRBI}(231,1793) = 31$$

$$\mathrm{BCBI}(i,j) = j - (\mathrm{CBI} - 1)\mathrm{BF}$$

$$\mathrm{BCBI}(231,1793) = 1793 - (36 - 1)50$$

$$\mathrm{BCBI}(231,1793) = 43$$

Within block 635, M(231,1793) is in row 31 and column 43. The position of the entry within the block can now be found.

$$\mathrm{BEN}(i,j) = \mathrm{BRBI} + \mathrm{BF}(\mathrm{BCBI} - 1)$$

$$\mathrm{BEN}(231,1793) = 31 + 50(43 - 1)$$

$$\mathrm{BEN}(231,1793) = 2131$$

M(231,1793) is mileage entry number 2131 within block 635. The word that contains entry 2131 must be calculated.

$$\mathrm{WN}(i,j) = [(\mathrm{BEN} - 1)/5] + 1$$

$$\mathrm{WN}(231,1793) = [(2131 - 1)/5] + 1$$

$$\mathrm{WN}(231,1793) = 427$$

M(231,1793) is in word 427 of block 635. The entry number within word 427 of block 635 must be calculated.

$$\mathrm{WEN}(i,j) = [\mathrm{MOD}(\mathrm{BEN} - 1),5] + 1$$

$$\mathrm{WEN}(231,1793) = [\mathrm{MOD}(2131 - 1),5] + 1$$

$$\mathrm{WEN}(231,1793) = 1$$

M(231,1793) is in the leftmost 12 bits (48-59) of word 427 of block 635. A logical AND can be done between word 427 and MASK(1), with the results in MENTRY, to remove the other four mileages.

```
MENTRY = MILARY(WN).AND.MASK(WEN)

MENTRY = MILARY(427).AND.MASK(1)
```

The final step is to shift the mileage entry into the rightmost part of the word so that it can be used as a normal variable.

```
     M(i,j) = SHIFT [MENTRY,12(WEN)]

M(231,1793) = SHIFT (MENTRY,12)

M(231,1793) = MENTRY
```

Only 12 bits had to be shifted since the entry was in the leftmost 12 bits. To avoid special cases and to make the shift procedure completely independent of the mileage position within the word, even when the entry is already in the rightmost 12 bits in the first place (WEN = 5), the shift function will result in a shift of all 60 bits (12 x 5 = 60), so MENTRY will still contain the correct value after execution of the shift.

RAIL MILES CALCULATION PROGRAM

A utility program (RAILCAL) allows rail mileage entries to be extracted as required from the rail mileage file. The program accepts two different types of requests. The first type of request allows a source rate basing point number (see the RBNSORT file format in section IV) and a destination rate basing point number to be provided, and the program will return the rail mileage between the two points. The second type of request allows a source rate basing point number and a radius to be provided, and the program will return all destination rate basing point numbers within the specified radius, along with the rail mileage from the specified source rate basing point.

Sample usage of the RAILCAL program during a time-sharing session is shown in Tables C-7 and C-8.

TABLE C-7. SAMPLE PROCEDURE FILE TO INTERACTIVELY EXECUTE

THE PROGRAM THAT EXTRACTS RAIL MILEAGES

```
  .
  .
  .
04860 1IRAIL,OLD,MESSAGE/UN=LIBRARY.
04880 MESSAGE.  EXECUTE RAIL MILEAGE CALCULATION PROGRAM
04900 GET,RAILCAL.
04920 FTN(I=RAILCAL,L=0)
04940 LGO.
04960 RETURN,RAILWA.
04980 MESSAGE.  RAIL CALCULATION END OF RUN.
05000 RETURN,MESSAGE.
05020 GOTO,9END.
05040 EXIT.
05060 MESSAGE.  RAIL CALCULATION PROGRAM ERROR
05080 MESSAGE.  DAYFILE TO FOLLOW.
05100 RETURN,MESSAGE,RAILWA.
05120 GOTO,9EXIT.
05140 9EXIT,PURGE,BYPDAY/NA.
05160 DEFINE,BYPDAY.
05180 DAYFILE,BYPDAY.
05200 REWIND,BYPDAY.
05220 COPYBF,BYPDAY.
05240 RETURN,BYPDAY.
05260 9END,EXIT.
  .
  .
  .
```

TABLE C-8. SAMPLE USAGE OF THE PROCEDURE FILE TO EXECUTE THE RAILCAL PROGRAM INTERACTIVELY

```
/OLD,PROCFIL
/-PROCFIL,S=1IRAIL.
 13.12.34.MESSAGE.  EXECUTE RAIL MILEAGE CALCULATION PROGRAM
  IF INSTRUCTIONS ARE REQUIRED ENTER YES
  ELSE ENTER NO
? YES
  THIS PROGRAM WILL PROVIDE THE RAIL MILEAGE
  BETWEEN ANY 2 RATE BASING POINT NUMBERS OR
  IT WILL PROVIDE ALL RATE BASING POINTS WITHIN
  A SPECIFIED RADIUS OF A SINGLE SOURCE RATE
  BASING POINT.
  IN EITHER CASE, A SOURCE NUMBER, A DESTINATION
  NUMBER, AND A RADIUS MUST BE SUPPLIED, SEPARATED
  BY COMMAS.
  IF BOTH A SOURCE NUMBER AND A NON-ZERO
  DESTINATION NUMBER ARE GIVEN, A RADIUS VALUE
  OF ZERO SHOULD BE ENTERED.
  IF A DESTINATION NUMBER OF ZERO IS GIVEN, ALL
  POTENTIAL DESTINATION POINTS WITHIN THE
  SPECIFIED RADIUS WILL BE PROVIDED.
  GREATER PROCESSING EFFICIENCY IS POSSIBLE IF
  SOURCE NUMBERS ARE ENTERED IN SEQUENCE.
  A CARRIAGE RETURN WILL TERMINATE PROGRAM
   EXECUTION WHEN ALL DATA HAS BEEN ENTERED.
ENTER SOURCE,DESTINATION,RADIUS
? 1095,1095,0

  FROM  1095  TO  1095 IS         20 RAIL MILES
ENTER SOURCE,DESTINATION,RADIUS
? 1,1,0

  FROM     1  TO     1 IS         20 RAIL MILES
ENTER SOURCE,DESTINATION,RADIUS
?1095,0,20

  POINTS WITHIN A    20 RAIL MILE RADIUS OF POINT 1095

 DISTANCE TO 1095 IS      20  RAIL MILES
 DISTANCE TO 1584 IS       0  RAIL MILES
 DISTANCE TO 1967 IS       0  RAIL MILES
 DISTANCE TO 2027 IS       0  RAIL MILES
 DISTANCE TO 2633 IS       0  RAIL MILES
 DISTANCE TO 2634 IS       0  RAIL MILES
 DISTANCE TO 2635 IS       0  RAIL MILES
 DISTANCE TO 2636 IS       0  RAIL MILES
 DISTANCE TO 2637 IS       0  RAIL MILES
 DISTANCE TO 2638 IS       0  RAIL MILES
 DISTANCE TO 2639 IS       0  RAIL MILES
ENTER SOURCE,DESTINATION,RADIUS
?
 13.13.53.MESSAGE.  RAIL CALCULATION END OF RUN.
9END,EXIT.
```